Archives of PHYSICAL MEDICINE

Official Journal American Congress of Physical Medicine

(Formerly Archives of Physical Therapy)

27th Annual Session

AMERICAN CONGRESS OF PHYSICAL MEDICINE

September 6, 7, 8, 9, 10, 1949

NETHERLAND PLAZA — CINCINNATI, OHIO

VOLUME XXX — JANUARY, 1949 — No. 1

American Congress of Physical Medicine

27th Annual
Scientific and Clinical Session
Instruction Course

September 6, 7, 8, 9 and 10, 1949

Official Headquarters

NETHERLAND PLAZA

Cincinnati, Ohio

EXECUTIVE OFFICES

30 NORTH MICHIGAN AVENUE CHICAGO 2, ILLINOIS

Contents — Jan. 1949

Volume XXX No. 1

ARCHIVES OF PHYSICAL MEDICINE
(Formerly Archives of Physical Therapy)
30 North Michigan Avenue, Chicago 2, Illinois

Subscription — In the United States, its possessions, and Mexico, $7.00 yearly; Canada, $8.00; elsewhere, $10.00 the year.

Advertising rates on application. All advertising copy subject to acceptance by publication committee.

Published monthly at Chicago, Illinois, by American Congress of Physical Medicine.

Entered as Second Class Matter, February 15, 1945, at the Post Office at Chicago, Illinois, under the Act of March 3, 1879.

ORIGINAL ARTICLES

EDITOR OF THE MONTH

RICHARD KOVACS, M.D.
New York, N. Y.

Printed in U.S.A.

Postgraduate Course in Physical Medicine and Rehabilitation

UNIVERSITY OF TEXAS, MEDICAL BRANCH, GALVESTON

FEBRUARY 28 - MARCH 4, 1949

TENTATIVE PROGRAM

All meetings, unless otherwise stated, will be held in the Amphitheater, 4th floor, Outpatient Building.

Monday, February 28 —

8:00 Registration

Morning Session — Wilbur A. Selle, Chairman

9:00 Opening Remarks....Truman G. Blocker and Chauncey D. Leake
9:15 The Challenge of Physical Medicine Rehabilitation in the Veterans Administration and in General Practice....A. B. C. Knudson
9:45 What Do We Mean by Rehabilitation — Why Is It Important?....A. W. Reggio
10:15 Intermission
10:25 Assistive and Supportive Apparatus in the Treatment of Muscle and Nerve Injuries....Robert L. Bennett
11:00 Aspects of the Backache Problem....James B. Mennell

Afternoon Session — Edward Randall, Chairman

1:30 Light Therapy....Richard Kovács
2:30 Physical Medicine in Army Hospitals....Lt. Col. Richard B. Dear, MC
3:00 Intermission
3:15 The Development and Progress of Corrective Therapy and Its Application to General Practice....John E. Davis
3:45 Work of the Council on Physical Medicine....Frederic T. Jung
4:15 Joint Application of Occupational Therapy and Physical Therapy in Physical Medicine....Ben. L. Boynton

Evening — Hotel Galvez — Movies

Tuesday, March 1st —

Morning Session — Stafford L. Osborne, Chairman

8:15 Hydrotherapy....Hans J. Behrend
9:00 Use of Aquatics in the Physical Reconditioning Program....Edward F. Quinn
9:30 The Use of Physical Agents in the Treatment of Arthritis....Sedgewick Mead
10:00 Physical Medicine in Relation to Geriatrics....Donald Erickson
10:30 Intermission
10:45 Manipulation of the Joints....James B. Mennell

Afternoon Session — G. W. N. Eggers, Chairman

1:30 Medical Diathermy....Stafford L. Osborne
2:30 Physical Medicine in Fractures....Miland E. Knapp
3:00 Intermission
3:10 Physical Medicine in Second and Third Degree Burns....A. E. White
3:40 Rehabilitation of the Tuberculosis Patient....Vincent J. Sutch
4:10 Quack Devices and Fallacies....Frederic T. Jung
4:40 Accidental Injuries in Physical Medicine....Richard Kovács

Evening — Hotel Galvez — Entertainment

Wednesday, March 2nd —

Morning Session — Oscar O. Selke, Chairman

8:15 Physiologic Basis for Heat and Cold....W. A. Selle
9:00 Fundamentals of Massage....James B. Mennell
10:00 Cervico-brachial Pain....Robcliff B. Jones
10:30 Functional Anatomy of the Upper Extremities....Donald Duncan
11:00 Gravitational Edema....Truman G. Blocker
11:30 Physical Medicine in Vascular Diseases....Sedgwick Mead

Afternoon Session — Chauncey D. Leake, Chairman

1:30	Low Frequency Currents	Richard Kovács
2:15	Minor Electric Surgery	Richard Kovács
2:50	Intermission	
3:00	Electrical Stimulation of Muscles	Stafford L. Osborne
3:30	Physiologic Basis for Therapeutic Exercise	Oscar O. Selke
4:15	The Role of Physical Medicine in Chest Diseases and Surgery	Florence Linduff

Evening Meeting — Hotel Galvez

Thursday, March 3rd —

Morning Session — A. B. C. Knudson, Chairman

8:15	Clinical Demonstrations	The Staff, University of Texas
9:00	Principles of Muscle Testing and Muscle Reeducation	Robert L. Bennett
10:00	Rehabilitation of the Paraplegic	Donald Erickson
10:30	Intermission	
10:45	Rehabilitation of the Amputee	Henry H. Kessler
11:30	Some Aspects of Atomic Energy in Physical Medicine	John Z. Bowers

Afternoon Session — Arild Hansen, Chairman

Symposium on Poliomyelitis and Cerebral Palsy

1:30	Management of Bulbar Poliomyelitis	C. G. Grulee
2:00	Treatment of the Muscular After Effects of Poliomyelitis	Miland E. Knapp
2:30	Intermission	
2:45	The Ideal Treatment Program for Poliomyelitis	Robert L. Bennett
3:30	General Aspects of Cerebral Palsy	M. A. Perlstein

Thursday Evening — Galvez Hotel — Annual Dinner

D. Bailey Calvin, Presiding

Friday, March 4th —

Morning Session — Ben L. Boynton, Chairman

8:15	Postural Exercises	Oscar Selke and Staff
9:00	"Wet Clinic" on Radioactive Isotopes	The Staff
10:00	Instrumentation for Therapeutic Radiosotope Application	W. A. Selle
10:30	Intermission	
10:40	Summaries and Round Table Discussions	Guest Speakers

Afternoon Session — Jack Ewalt, Chairman

Symposium on Physical Medicine in Neuropsychiatry

1:30	The Place of Physical Medicine in Psychiatry	A. B. C. Knudson
2:00	Corrective Therapy, an Individualized Approach to the Mental Patient	John E. Davis
2:30	Rehabilitation of the Neurotic Patient ....(Discussions by Martin E. Grobman, S. Charles Burlingame, Jack Ewalt)	
4:00	Closing Remarks—Chauncey D. Leake.	

Registration — In order to determine what attendance may be expected, those planning to participate are requested to register in advance with Dr. T. G. Blocker, Director of Postgraduate Study. A tuition fee of $25.00 for physicians and administrators and $15.00 for registered technicians will be charged. An additional $2.00 fee will be charged those desiring certification of attendance at the Course.

Hotel Reservations — Individuals will be expected to make their own room reservations with Hotel Galvez, headquarters.

For further information regarding the course, write: Dr. W. A. Selle, Director of Postgraduate Course in Physical Medicine, University of Texas, Medical Branch, Galveston.

THE EFFECT OF MICROWAVE DIATHERMY ON THE PERIPHERAL CIRCULATION AND ON TISSUE TEMPERATURE IN MAN *

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Microwaves are electromagnetic radiations with wavelengths between 1 meter and 1 millimeter.[1] This corresponds to a frequency range of 300 to 300,000 megacycles per second. Their optical properties, which enable them to be reflected, refracted, diffracted and polarized, may make these radiations convenient for therapeutic use, for they can be focused and directed. Microwaves could be used therapeutically to produce heat, when an oscillator with sufficient power output could be manufactured. The magnetron, an oscillator which could generate microwaves, was described by A. W. Hull[2] in 1921, but its output was too low. During the two decades from 1921 to 1940, a few types of magnetrons were developed, with progressive increases in the power output and frequency. By 1940 the British had developed the magnetron to the point at which there was a high power output even at the highest frequencies of the microwave range.[3] This multicavity magnetron was brought to the United States, and the first American experiment was performed on Oct. 6, 1940.[4] Although the energy output was sufficiently high, the use of the magnetron for military purposes prevented investigation of its therapeutic potentialities at that time.

The first reports concerning the biologic effects of microwaves appeared during World War II and were concerned with very short bursts of energy, such as were used in connection with radar work. Follis[5] showed that radiations of this type had no ill effects on guinea pigs. Leden and associates[6] studied the effects of microwaves on trained and anesthetized dogs and found that there was an increase of cutaneous, subcutaneous and muscle temperatures in the exposed extremity, accompanied with an increase of blood flow. Worden[7] and his co-workers found increases in the temperature of normal and ischemic tissue in the dog after exposure to microwaves. Kemp and his associates[8] reported an increase of blood flow in the anesthetized dog after microwave diathermy. After having obtained definite heating of

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* Abridgment of a thesis submitted by Dr. Gersten to the Faculty of the Graduate School, University of Minnesota, in partial fulfilment of the requirements for the degree of Master of Science in Physical Medicine.

* Read at the Twenty-Sixth Annual Session of the American Congress of Physical Medicine, Washington, D. C., Sept. 11, 1948.

1. Brownell, A. B., and Beam, R. E.: Theory and Application of Microwaves, ed. 1, New York, McGraw-Hill, 1947.
2. Hull, A. W.: Physical Rev. **18**:31, 1921.
3. Hagstrum, H. D.: Proc. Institute Radio Engineers **35**:548, 1947.
4. Fisk, J. B.; Hagstrum, H. D., and Hartman, P. L.: Bell System Tech. J. **25**:167, 1946.
5. Follis, R. H., Jr.: Am. J. Physiol. **147**:281, 1946.
6. Leden, Ursula M.; Herrick, J. F.; Wakim, K. G., and Krusen, F. H.: Brit. J. Phys. Med. **10**:177, 1947.
7. Worden, R.: Unpublished data.
8. Kemp, C. R.; Paul, W. D., and Hines, H. M.: Arch. Phys. Med. **29**:12, 1948.

tissues in animals in our laboratories on exposure of various regions of the body to microwaves, we decided to study the effects of microwaves on normal human beings. The purpose of this study was to determine the effect of various outputs of microwaves and of different periods of exposure to microwave diathermy on the peripheral circulation and on the tissue temperature in the exposed limb of man. Special attention was directed toward the determination of the optimal effects on tissue temperature and on the peripheral circulation.

Method

This study was made on 50 normal human subjects, 37 men and 13 women. The total number of observations made was 254. These were divided into two groups, one of which consisted of temperature studies and the other of blood flow studies. In the group in which attention was directed primarily toward tissue temperature, the temperatures were recorded by means of copper-constantan thermocouples. The muscle thermocouple was inserted to a depth of 1.5 cm. The subcutaneous thermocouple was 1.9 cm. long and was inserted so that the entire shaft was underneath the skin, with the recording tip near the shaft of the muscle thermocouple. The cutaneous thermocouple was placed on the skin close to the other two but not in contact with either. It was weighted so that it would exert identical pressure on the skin in all observations. The three thermocouples were placed in the zone of maximal energy according to antenna pattern, which in this case is 3 mm. outside the outer margin of the director of the microwave generator, in an area where there were no visible blood vessels. The galvanometer deflection which resulted from the difference of temperature between the reference and the recording thermocouples was recorded visually. The studies on blood flow were done on the exposed and on the contralateral extremity with the venous occlusion plethysmograph and the compensating spirometer recorder.[9]. In the group in which observations on blood flow were made, the cutaneous temperature was taken both on the exposed and on the unexposed extremity by means of a thermistor.

The source of the microwaves to which the forearm was exposed was the air-cooled multicavity magnetron. The frequency of these electromagnetic radiations was 2,450 megacycles per second (corresponding to a wavelength of approximately 12 cm.). The energy was transported from the oscillator to the director by means of a coaxial cable. The hemispherical director, with a diameter of approximately 9 cm., was used in this study. The distance from director to skin was 5 cm. in all the observations.

Control readings of peripheral blood flow or temperature of the tissues or both were determined after the subject had been lying quietly for at least half an hour in a room the temperature of which did not vary during the observations. Exposure to the microwaves was not begun until the blood flow and the temperature were fairly constant. The microwaves were applied to the volar surface of the forearm, with the proximal margin of the director approximately 8 cm. from the elbow. In all but 26 observations blood flow readings were taken five minutes after the end of the period of exposure to the microwaves. In these 26 observations, which will be referred to later, the first blood flow readings were taken on an average of 6.8 minutes after the microwaves had been turned off. In some experiments additional blood flow determinations were made ten minutes after exposure to microwaves. In those subjects on whom blood flow studies were made, the cutaneous temperature was taken on the exposed extremity immediately after exposure to microwaves and again one minute after. The temperature of the unexposed extremity was taken one minute after exposure to microwaves. In those subjects whose temperatures were taken by means of thermocouples the first readings were taken one minute after the end of heating. Since the thermocouples could not be left in place during the period of exposure because of the heating which occurs in metals in the radiation field, marks were made on the skin so that they would be inserted at the same place. Additional readings were often taken every minute for five minutes, while in a few subjects the temperature study was continued for forty minutes, with readings taken at five-minute intervals.

In 133 observations the oral temperature was taken, and in 73 observations the pulse rate also was taken before and after exposure to microwaves.

9. Berry, M. R.; Baldes, E. J.; Essex, H. E., and Wakim, K. G.: J. Lab. & Clin. Med. 33:101, 1948.

Results

Temperature Studies (Table 1; Charts 1, 2, and 3). — One Minute of Exposure at 80 Watts (10 Observations): The average rise of cutaneous temperature was 1.6 degrees C., with a range from 0.8 to 2.2 degrees; the average rise of subcutaneous temperature was 1.8 degrees C., with a range from 1.3 to 2.6 degrees; the average rise of muscle temperature was 1.4 degrees, with a range from 1.0 to 1.7 degrees. The maximal temperature reached in the skin was 35.8 C.; in the subcutaneous tissue and in the muscle the maximal temperature was 36.7 C. In 3 observations the greatest rise of temperature took place in the skin; in 4 the greatest rise occurred in the subcutaneous tissue; in 2 the rise of temperature was the same in skin and subcutaneous tissue, and in 1 the rise of temperature of subcutaneous tissue and muscle was the same. The preheating temperature was highest in the muscle in all 10 observations. After the completion of the exposure to microwaves, the temperature was highest in the muscle in 8 observations and highest in the subcutaneous tissue in 2.

TABLE 1. — *Effect of Microwaves on Temperature of Skin, Subcutaneous Tissue and Muscle.*

Dosage, Watts	Duration of Heating, Min.	Observations	Cutaneous Temperature, °C. Before Exposure Mean	S.D.	After Exposure Mean	S.D.	Increase Mean	S.D.	Subcutaneous Temperature, °C. Before Exposure Mean	S.D.	After Exposure Mean	S.D.	Increase Mean	S.D.	Muscle Temperature, °C. Before Exposure Mean	S.D.	After Exposure Mean	S.D.	Increase Mean	S.D.
80	1	10	33.8	0.30	35.4	0.26	1.6	0.47	34.3	0.28	36.1	0.31	1.8	0.45	34.8	0.20	36.2	0.20	1.4	0.23
80	5	26	32.8	0.96	37.3	1.14	4.5	1.02	33.6	1.07	38.8	1.25	5.2	1.31	34.0	1.28	39.5	1.34	5.5	1.19
80	10	25	33.5	0.97	38.3	1.07	4.8	1.38	33.9	1.20	39.6	1.42	5.7	1.86	34.7	1.10	40.8	1.93	6.1	1.43
80	15	10	32.7	1.47	37.5	0.61	4.8	1.72	33.8	1.84	39.3	0.64	5.5	2.38	34.4	1.66	41.1	0.56	6.7	1.32
80	20	25	33.5	0.97	38.2	1.43	4.7	1.64	33.9	1.20	39.7	1.51	5.8	1.81	34.7	1.10	41.4	1.40	6.7	1.74
80	25	10	33.7	0.46	38.0	0.46	4.3	0.77	34.0	0.42	39.0	0.53	5.0	0.65	34.7	0.24	40.0	0.82	5.3	0.84
80	30	10	33.0	0.45	35.9	0.57	2.9	1.01	34.2	0.64	37.6	0.78	3.4	1.28	34.7	0.46	39.0	1.02	4.3	1.29
60	15	10	33.5	0.74	37.6	0.49	4.1	0.80	34.5	0.63	39.3	0.63	4.8	1.00	34.7	0.60	40.9	0.28	6.2	0.62
60	20	10	32.4	0.75	37.4	0.85	5.0	0.75	33.4	0.70	38.8	1.05	5.4	1.11	34.3	0.64	40.9	0.72	6.6	0.63
60	30	10	33.0	0.31	36.7	0.56	3.7	0.60	34.2	0.40	38.2	0.79	4.0	0.84	34.8	0.32	40.2	0.84	5.4	0.83

Five Minutes of Exposure at 80 Watts (26 Observations): The average rise of cutaneous temperature was 4.5 degrees C., with a range from 3.0 to 7.3 degrees; the average rise of subcutaneous temperature was 5.2 degrees, with a range from 2.3 to 7.5 degrees; the average rise of muscle temperature was 5.5 degrees, with a range from 3.9 to 8.6 degrees. The maximal temperature reached was 39.4 C. in the skin, 41.2 C. in the subcutaneous tissue and 41.7 C. in the muscle. In 10 observations the greatest rise of temperature took place in the subcutaneous tissue; in 14 the greatest increase occurred in the muscle; in 1 observation the rise of cutaneous and subcutaneous temperature was the same, while in 1 instance the rise of subcutaneous and muscle temperature was identical. The preheating temperature was highest in the subcutaneous tissue in 4 observations and highest in the muscle in 22. After exposure to microwaves the temperature was highest in the subcutaneous tissue in 4 and highest in the muscle in 22 observations.

Ten Minutes of Exposure at 80 Watts (25 Observations): The average rise of cutaneous temperature was 4.8 degrees C., with a range from 1.9 to 8.8 degrees; the average rise of subcutaneous temperature was 5.7 degrees, with a range from 2.7 to 10.6 degrees; the average rise of muscle temperature was 6.1 degrees, with a range from 2.8 to 9.1 degrees. The maximal temperature reached was 40.9 C. in the skin, 43.0 C. in the subcutaneous tissue and 44.2 C. in the muscle. The greatest rise of temperature occurred in the muscle in 13 observations, in the subcutaneous tissue in 10 observa-

tions and in the skin in only 2 observations. The preheating temperature was highest in the subcutaneous tissues in 3 observations, highest in the muscle in 21 and identical in subcutaneous tissue and muscle in 1. The temperature after heating was highest in the skin in 1 instance, highest in the subcutaneous tissue in 4 and highest in the muscle in 20.

Fifteen Minutes of Exposure at 80 Watts (10 Observations): The average rise of cutaneous temperature was 4.8 degrees C., with a range from 2.6 to 7.8 degrees; the average rise of subcutaneous temperature was 5.5 degrees, with a range from 1.8 to 8.9 degrees; the average rise of muscle temperature was 6.7 degrees, with a range from 5.2 to 9.3 degrees. The maximal temperature reached was 38.6 C. in the skin, 40.2 C. in the subcutaneous tissue and 42.0 C. in the muscle. The greatest rise of temperature took place in the subcutaneous tissue in 2 observations and in the muscle in 8. The preheating temperature was highest in the subcutaneous tissue in 1 observation, highest in the muscle in 7 and identical in subcutaneous tissue and muscle in 2. The temperature after exposure to microwaves was highest in the muscle in all 10 observations.

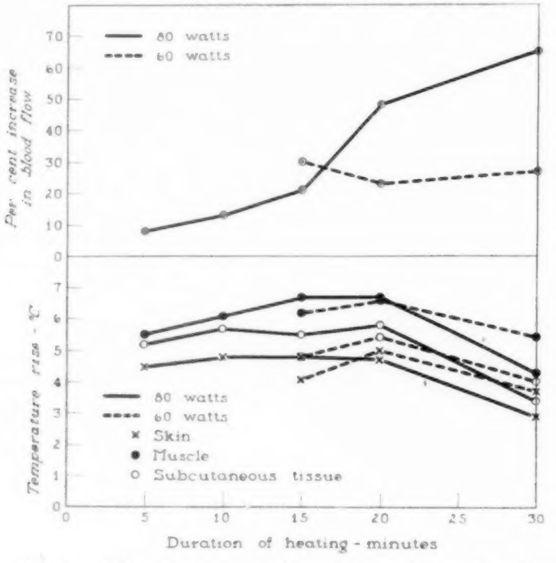


Chart 1. — Effects of exposure to microwaves (60 and 80 watts) on blood flow and on tissue temperature in the treated extremity. Blood flow readings were taken five minutes after microwaves had been turned off. Temperature readings were taken one minute after microwaves had been turned off. Each point is the average of 9 to 26 observations, as indicated in tables 1 and 3.

Twenty Minutes of Exposure at 80 Watts (25 Observations): The average rise of cutaneous temperature was 4.7 degrees C., with a range from 1.1 to 9.3 degrees; the average rise of subcutaneous temperature was 5.8 degrees, with a range from 3.1 to 9.9 degrees; the average rise of muscle temperature was 6.7 degrees, with a range from 2.8 to 11.1 degrees. The maximal temperature reached was 42.8 C. in the skin, 44.2 C. in the subcutaneous tissue and 45.0 C. in the muscle. The greatest rise of temperature occurred in the skin in 1 observation, in the subcutaneous tissue in 5 and in the muscle in 18, while in 1 observation the rise of temperature of sub-

cutaneous tissue and muscle was the same. The temperature before exposure to microwaves was highest in the subcutaneous tissue in 3 observations and highest in the muscle in 21, while in 1 these two tissues were at the same temperature. After heating, the temperature was highest in the

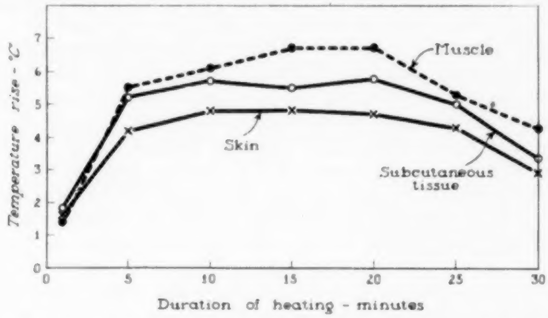


Chart 2. — Effects of exposure to microwaves (80 watts) on tissue temperature in the treated extremity. Temperature readings were taken one minute after microwaves had been turned off. Each point is the average of 10 to 26 observations, as indicated in table 1.

skin in 1 observation, highest in the subcutaneous tissue in 2, highest in the muscle in 21 and the same in subcutaneous tissue and muscle in 1.

Twenty-Five Minutes of Exposure at 80 Watts (10 Observations): The average rise of cutaneous temperature was 4.3 degrees C., with a range from 3.5 to 5.8 degrees; the average rise of subcutaneous temperature was 5.0 degrees, with a range from 4.3 to 6.6 degrees; the average rise of muscle temperature was 5.3 degrees, with a range from 4.1 to 6.5 degrees. The

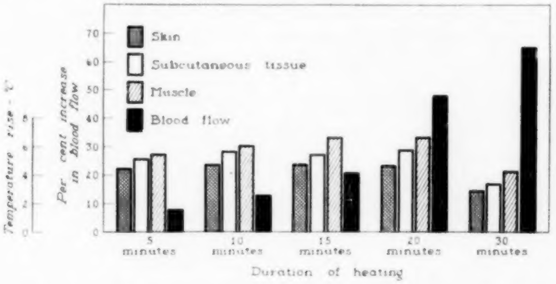


Chart 3. — Effects of exposure to microwaves (80 watts) on blood flow and on tissue temperature in the treated extremity. Blood flow readings were taken five minutes after the microwaves had been turned off. Temperature readings were taken one minute after the microwaves had been turned off. The height of each bar represents the average of 9 to 26 observations, as indicated in tables 1 and 3.

maximal temperature reached was 38.9 C. in the skin, 39.7 C. in the subcutaneous tissue and 41.0 C. in the muscle. The greatest rise of temperature took place in the subcutaneous tissue in 4 observations and in the muscle in 6. The temperature was highest in the muscle before and after exposure to microwaves in all 10 observations.

Thirty Minutes of Exposure at 80 Watts (10 Observations): The average rise of cutaneous temperature was 2.9 degrees C., with a range from 1.0 to 4.3 degrees; the average rise of subcutaneous temperature was 3.4 degrees, with a range from 0.8 to 4.9 degrees; the average rise of muscle temperature

was 4.3 degrees, with a range from 1.3 to 6.0 degrees. The maximal temperature reached was 36.7 C. in the skin, 38.7 C. in the subcutaneous tissue and 40.3 C. in the muscle. In 1 observation the greatest temperature rise occurred in the subcutaneous tissue, while in the other 9 the greatest increase took place in the muscle. In all 10 observations the highest temperature was in the muscle both before and after exposure to microwaves.

Fifteen Minutes of Exposure at 60 Watts (10 Observations): The average rise of cutaneous temperature was 4.1 degrees C., with a range from 3.2 to 5.4 degrees; the average rise of subcutaneous temperature was 4.8 degrees, with a range from 3.2 to 6.0 degrees; the average rise of muscle temperature was 6.2 degrees, with a range from 5.1 to 6.9 degrees. The maximal temperature reached was 38.3 C. in the skin, 40.2 C. in the subcutaneous tissue and 41.3 C. in the muscle. In all 10 observations the greatest temperature rise occurred in the muscle. Before exposure to microwaves the temperature was highest in the subcutaneous tissue in 1 observation, highest in the muscle in 7 observations and identical in the two tissues in 2 observations. After exposure to microwaves the temperature was highest in the muscle in all 10 observations.

Twenty Minutes of Exposure at 60 Watts (10 Observations): The average rise of cutaneous temperature was 5.0 degrees C., with a range from 3.8 to 5.8 degrees; the average rise of subcutaneous temperature was 5.4 degrees, with a range from 3.7 to 7.0 degrees; the average rise of muscle temperature was 6.6 degrees, with a range from 5.5 to 7.8 degrees. The maximal temperature reached was 38.5 C. in the skin, 40.1 C. in the subcutaneous tissue and 42.1 C. in the muscle. The greatest rise of temperature took place in the subcutaneous tissue in 1 observation and in the muscle in 9 observations. The preheating and the postheating temperatures were highest in the muscle in all 10 observations.

Thirty Minutes of Exposure at 60 Watts (10 Observations): The average rise of cutaneous temperature was 3.7 degrees C., with a range from 2.3 to 4.2 degrees; the average rise of subcutaneous temperature was 4.0 degrees, with a range from 2.2 to 5.2 degrees; the average rise of muscle temperature was 5.4 degrees, with a range from 4.0 to 6.4 degrees. The maximal temperature reached was 37.4 C. in the skin, 39.6 C. in the subcutaneous tissue and 41.3 C. in the muscle. The greatest rise of temperature occurred in the muscle in all 10 observations. Both the preheating and the postheating temperatures were highest in the muscle in all 10 observations.

Rate of Cooling: In 51 observations the temperatures of the skin, subcutaneous tissue and muscle were recorded every minute for five minutes after the microwaves had been turned off. For all three tissues the rate of reduction of temperature decreased with the passage of time. During the second minute after the microwaves had been turned off, the greatest reduction of temperature occurred in the subcutaneous tissue. After that the fall of temperature was greatest in the muscle (table 2; chart 4). In 11 observations the temperatures were recorded for fifteen minutes or longer after the termination of exposure to microwaves. In 9 of these observations exposure was for five minutes at 80 watts, and in 2 it was for twenty minutes at 60 watts. In 1 of these 11 observations the subcutaneous temperature returned to the control level forty-five minutes after the microwaves had been turned off. In no other instance did the temperature return to the control value during the period of observation.

Site of Highest Temperature: Temperature studies of the tissues were

done in 146 observations. The control temperature was highest in the subcutaneous tissue in 12, was highest in the muscle in 128 and was the same in subcutaneous tissue and muscle in 6. After exposure to microwaves the temperature was highest in the skin in 2, in the subcutaneous tissue in 10 and in the muscle in 133 and was the same in subcutaneous tissue and muscle in 1. In these 146 observations the preheating temperature gradient was changed in only 8 observations as a result of exposure to microwaves. In these 8 observations the changes of temperature gradient were as follows: In 5 the preheating temperature was the same in subcutaneous tissue and muscle, while, after heating, the temperature was highest in the muscle; in 1 the highest control temperature was in the subcutaneous tissue, and, after heating, it was in the skin; in 1 the highest control temperature was in the subcutaneous tissue, and, after heating, it was in the muscle; in the remaining 1 the highest preheating temperature was in the muscle, while the highest temperature after heating was in the skin.

TABLE 2. — *Change of Tissue Temperature After Cessation of Heating.*

Time After Cessation of Heating, Minutes	Temperature Decrease, Degrees Centigrade Skin	Subcutaneous Tissue	Muscle
1 to 2	0.46	0.72	0.64
2 to 3	0.36	0.44	0.53
3 to 4	0.23	0.30	0.41
4 to 5	0.19	0.20	0.33

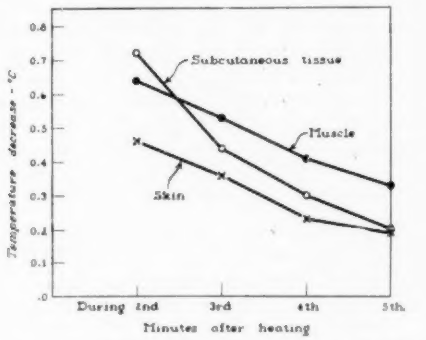


Chart 4. — Decrease of temperature of skin, subcutaneous tissue and muscle after microwaves had been turned off (for example, the temperature decrease during the second minute after the microwaves had been turned off is equal to the temperature at one minute minus that at two minutes). Each point is the average of 51 observations.

Blood Flow Studies (Tables 3 and 4; Charts 1 and 3). — Five Minutes of Exposure at 80 Watts (20 Observations): There was an average increase of 8 per cent in the blood flow in the exposed extremity, with a range from -25 per cent to +44 per cent. In the unexposed extremity there was an average decrease of blood flow of 2 per cent. The average increase of cutaneous temperature in the exposed extremity was 5.0 degrees C. immediately after and 4.2 degrees one minute after the microwaves had been turned off. The average rise of cutaneous temperature in the unexposed extremity was 0.2 degree C. In 6 observations in which oral temperature was taken before and after exposure to microwaves, it averaged 98.5 F. both before and after exposure.

Ten Minutes of Exposure at 80 Watts (20 Observations): There was

an average increase of 13 per cent in the blood flow in the exposed extremity, with a range from -5 per cent to +40 per cent. In the unexposed extremity there was an average decrease of blood flow of 5 per cent. The average rise of cutaneous temperature in the exposed extremity was 5.2 degrees C. immediately after exposure to microwaves and 4.5 degrees one minute after. The average rise of cutaneous temperature in the unexposed extremity was 0.1 degree C. Oral temperature was taken in all 20 observations. The average oral temperature remained the same before and after heating — namely, 98.4 F.

TABLE 3. — *Effects of Microwaves on the Blood Flow in the Treated Extremity*

Output, Watts	Duration of Heating, Min.	Observations	Flow Before Heating, Cc. Per Min.		Flow After Heating, Cc. Per Min.		Increase of Flow, Cc. Per Min.		Percentage* Increase of Flow		Flow Before Heating, Cc. Per 100 Cc.		Flow After Heating, Cc. Per 100 Cc.		Increase of Flow, Cc. Per 100 Cc.		Percentage† Increase of Flow,
			Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean
80	5	20	161	59.4	176	75.9	15	31.0	8	17.5	9.16	3.14	9.94	4.04	0.8	1.9	8
80	10	20	162	57.3	179	75.2	17	21.9	12	13.3	9.10	3.58	10.30	3.82	1.2	1.3	13
80	15	9	109	39.3	135	50.0	26	26.1	25	19.3	7.76	2.42	9.42	1.93	1.7	1.5	21
80	17	10	96	26.0	127	20.1	31	18.5	38	29.5	5.67	1.21	7.59	1.31	1.9	1.4	33
80	20	20	104	50.2	151	61.8	48	26.1	55	37.0	6.90	2.50	10.20	2.62	3.3	1.7	48
80	25	10	95	23.8	158	25.3	63	21.0	75	48.4	5.50	1.21	9.25	1.74	3.7	1.5	67
80	27	10	91	21.8	150	34.7	59	20.0	67	21.8	6.68	2.46	10.61	3.04	3.9	1.2	59
80	30	10	109	59.2	173	59.5	63	40.0	76	57.3	6.93	2.42	11.45	3.32	4.5	3.1	65
60	15	10	117	31.9	153	41.4	36	23.6	33	22.9	8.27	2.98	10.76	3.63	2.5	1.6	30
60	20	13	81	31.6	97	36.5	17	22.9	27	33.6	6.58	2.08	8.12	3.26	1.5	2.3	23
60	30	12	98	43.1	124	49.0	26	23.1	37	36.5	6.84	2.46	8.71	2.12	1.9	1.7	27

* Average of the percentage increase for all observations in a group (as indicated under the number of observations).

† Ratio of the average increase of flow after heating to the average flow before heating, in cc. per 100 cc. of tissue.

Fifteen Minutes of Exposure at 80 Watts (9 Observations): The average increase of blood flow in the exposed extremity five minutes after the microwaves had been turned off was 21 per cent, with a range from —10 per cent to +48 per cent. Ten minutes after heating the average increase of blood flow in the treated extremity was 14 per cent. In the unexposed extremity there was an average decrease of blood flow of 10 per cent. In the exposed extremity the average rise of cutaneous temperature immediately after the microwaves had been turned off was 6.0 degrees C., while, one minute after, it was 5.1 degrees. The average rise of cutaneous temperature

TABLE 4. — *Effect of Microwaves on the Blood Flow in the Untreated Extremity.*

Output, Watts	Duration of Heating, Minutes	Observations	Flow Before Heating, Cc. Per 100 Cc		Flow After Heating, Cc. Per 100 Cc.		Change of Flow, Cc. Per 100 Cc.		S. E.* Cc. Per 100 Cc.	t	P	Change of Flow, Percent
			Mean	S.D.	Mean	S.D.	Mean	S.D.				
80	5	20	9.87	4.00	9.65	4.54	—0.22	1.98	0.45	0.49	0.7–0.6	—2
80	10	20	9.10	3.59	8.60	3.40	—0.50	1.07	0.24	2.08	0.05	—5
80	15	9	7.76	2.50	6.96	2.18	—0.80	1.13	0.38	2.18	0.1–0.05	—10
80	17	10	7.12	1.73	7.13	1.66	+0.01	1.33	0.42	0.02	>0.9	0
80	20	20	7.60	3.24	8.00	3.52	+0.40	1.41	0.32	1.25	0.3–0.2	+5
80	20†	26	8.20	2.04	7.30	2.26	—0.90	2.72	0.53	1.70	0.1	—11
80	25	10	5.60	1.17	6.24	1.37	+0.64	0.77	0.24	2.66	0.05–0.02	+11
80	27	10	6.65	1.64	6.66	1.01	+0.01	1.34	0.42	0.72	>0.09	0
80	30	10	7.24	2.73	7.79	1.82	+0.55	2.24	0.71	0.77	0.5–0.4	+8
60	15	10	8.05	2.36	8.29	2.39	+0.24	2.12	0.67	0.36	0.8–0.7	+3
60	20	13	7.06	3.30	6.05	1.83	—1.01	2.73	0.76	1.33	0.3–0.2	—14
60	30	12	6.79	2.18	7.03	2.44	+0.24	1.85	0.54	0.44	0.7–0.6	+4

* Standard error of mean change.

† Blood flow readings in this group of observations were taken on an average of 6.8 minutes after cessation of exposure to microwaves.

of the unexposed extremity was 0.6 degree. In 19 observations (which included the group in which temperature studies were made) the average oral temperature both before and after heating was 98.4 F. The average pulse rate in these observations was 67 per minute before and remained the same after microwave diathermy.

Seventeen Minutes of Exposure at 80 Watts (10 Observations): The average increase of blood flow in the exposed extremity was 33 per cent, with a range from –4 per cent to +93 per cent. In the unexpected extremity there was no change of blood flow.

Twenty Minutes of Exposure at 80 Watts (46 Observations): In 20 of the 46 observations the first blood flow readings after heating were made five minutes after the completion of the twenty-minute exposure to microwaves. The average increase of blood flow in these 20 observations was 48 per cent, with a range from —4 per cent to +174 per cent. At ten minutes the average increase of blood flow was 43 per cent. In the unexposed extremity there was an average increase of blood flow of 5 per cent. In 26 of the 46 observations the first studies were made on an average of 6.8 minutes after the twenty-minute exposure to microwaves. In these 26 observations the average increase of blood flow was 40 per cent, with a range from –37 per cent to +120 per cent. In the unheated extremity there was an average decrease of blood flow of 11 per cent. Immediately after heating, the average rise of cutaneous temperature in the heated extremity was 5.6 degrees C., while, one minute after, the rise was 4.8 degrees. The rise of cutaneous temperature of the unheated extremity was, on the average, 0.7 degree C. Oral temperature was taken before and after heating in 30 observations. The average preheating temperature was 98.2 F., while the average postheating temperature was 98.3 F.

Twenty-Five Minutes of Exposure at 80 Watts (10 Observations): The average increase of blood flow in the treated extremity was 67 per cent, was with a range from +30 per cent to +202 per cent. Although it is this value (67 per cent) which is plotted in the curve analysis to be considered later, it should be noted that 1 observation was far above the range of increase of the other 9 observations. If this value (+202 per cent) is omitted, the average increase of blood flow becomes +59 per cent, with a range from +30 per cent to +88 per cent. This value is much closer to the theoretical curve derived. In the unexposed extremity there was an average increase of blood flow of 11 per cent.

Twenty-Seven Minutes of Exposure at 80 Watts (10 Observations): The average increase of blood flow in the extremity exposed to microwaves was 59 per cent, with a range from +32 per cent to +98 per cent. In the unexposed extremity the average flow before exposure to microwaves was the same as that after exposure.

Thirty Minutes of Exposure at 80 Watts (10 Observations): The average increase of blood flow in the heated extremity five minutes after the microwaves had been turned off was 65 per cent, with a range from +11 per cent to +199 per cent. At ten minutes the average increase of flow was 59 per cent. In the unheated extremity there was an average increase of blood flow of 8 per cent. Immediately after exposure to microwaves the average rise of cutaneous temperature in the heated extremity was 4.4 degrees C., while at one minute the average rise was 3.6 degrees. The average rise of cutaneous temperature in the unheated extremity was 0.3 degree. Oral temperatures were taken in 19 observations (including the group in which temperature studies were made). The average preheating temperature was

98.3 F., while the average postheating temperature was 98.5 F. In these 19 observations the average pulse rate before heating was 67 per minute, while after heating it was 65 per minute.

Fifteen Minutes of Exposure at 60 Watts (10 Observations): The average increase of blood flow in the heated extremity five minutes after the microwaves had been turned off was 30 per cent, with a range from –3 per cent to +73 per cent. Ten minutes after exposure to microwaves the average increase of blood flow was 37 per cent. In the unexposed extremity there was an average increase of blood flow of 3 per cent. In 12 observations (including the group in which temperature studies were made) the average preheating oral temperature was 98.1 F. and the average postheating temperature was 98.2 F. In these 12 observations the average pulse rate before heating was 66 per minute and, after heating, it was 67 per minute.

Twenty Minutes of Exposure at 60 Watts (13 Observations): Five minutes after exposure to microwaves the average increase of blood flow of the heated extremity was 23 per cent, with a range from –30 per cent to +92 per cent. Ten minutes after heating, the average increase of flow was still 23 per cent. In the unheated extremity there was an average decrease of blood flow of 14 per cent. Immediately after exposure to microwaves the average rise of cutaneous temperature in the heated extremity was 5.9 degrees C., while after one minute the average rise was 5.2 degrees. The average rise of cutaneous temperature of the unheated extremity was 0.5 degree. In 14 observations (including the group in which temperature studies were made) the average preheating oral temperature was 98.4 F., while the average temperature after heating was 98.5 F. The average control pulse rate in 8 observations was 65 per minute and, after heating, it was 69 per minute.

Thirty Minutes of Exposure at 60 Watts (12 Observations): Five minutes after the microwaves had been turned off there was an average increase of the blood flow of the heated extremity of 27 per cent, with a range from –28 per cent to +104 per cent. At ten minutes the average increase of blood flow was 19 per cent. In the unexposed extremity there was an average increase of blood flow of 4 per cent. Immediately after the microwaves had been turned off, the average rise of cutaneous temperature in the heated extremity was 4.9 degrees C. and one minute after, it was 4.2 degrees. The average rise of cutaneous temperature of the unheated extremity was 0.7 degree. In 13 observations (including the group in which temperature studies were made) the average preheating oral temperature was 98.3 F., while after heating it was 98.4 F. The average control pulse rate was 67 per minute, and the pulse rate remained unchanged after heating.

Statistical Analysis of Data

Although the average increase of temperature was greater for muscular tissue than for skin or subcutaneous tissue in every group but one (exposure for one minute at 80 watts), it was important to determine how significant this difference in temperature rise was. In tables 5 and 6 a comparison between the heating of skin, subcutaneous tissue and muscle is given. The temperature rise of muscle was significantly greater than that of subcutaneous tissue, while the temperature rise of subcutaneous tissue was significantly greater than that of skin.

Another important problem was the comparison of blood flow and tissue temperature after identical periods of exposure, but at different outputs. Chart 5 shows the difference in effect between 60 watt and 80 watt exposure.

Tables 7 and 8 give the statistical data which enable one to compare the effect of the two outputs used in this study.

After comparing the effects of different outputs at any given time interval, we studied the effect of various durations of heating at one output. The temperature changes after exposure of the forearm for different periods at 60 and at 80 watts and the change of blood flow after exposure at 60 watts

TABLE 5. — *Comparison of Temperature Rise of Skin, Subcutaneous Tissue and Muscle After Exposure to Microwaves.*

Data Compared	Observations	Difference Between Means, °C.	Standard Error, °C.	t	P
1 minute heat; 80 watts	10 + 10				
Subcutaneous > skin		0.2	0.20	1.00	0.4–0.3
Subcutaneous > muscle		0.4	0.16	2.50	0.02
Skin > muscle		0.2	0.17	1.18	0.3–0.2
5 minutes heat; 80 watts	26 + 26				
Subcutaneous > skin		0.7	0.33	2.12	0.05–0.02
Muscle > subcutaneous		0.3	0.35	0.86	0.4–0.3
Muscle > skin		1.0	0.30	3.33	0.001
10 minutes heat; 80 watts	25 + 25				
Subcutaneous > skin		0.9	0.46	1.96	0.05
Muscle > subcutaneous		0.4	0.47	0.85	0.4–0.3
Muscle > skin		1.3	0.40	3.25	0.01–0.001
15 minutes heat; 80 watts	10 + 10				
Subcutaneous > skin		0.7	0.93	0.75	0.5–0.4
Muscle > subcutaneous		1.2	0.86	1.39	0.2–0.1
Muscle > skin		1.9	0.66	2.88	0.02–0.01
20 minutes heat; 80 watts	25 + 25				
Subcutaneous > skin		1.1	0.49	2.24	0.05–0.02
Muscle > subcutaneous		0.9	0.50	1.80	0.1–0.05
Muscle > skin		2.0	0.48	4.16	<0.001
25 minutes heat; 80 watts	10 + 10				
Subcutaneous > skin		0.7	0.32	2.19	0.05–0.02
Muscle > subcutaneous		0.3	0.34	0.88	0.4–0.3
Muscle > skin		1.0	0.36	2.78	0.01
30 minutes heat; 80 watts	10 + 10				
Subcutaneous > skin		0.5	0.52	0.95	0.4–0.3
Muscle > subcutaneous		0.9	0.58	1.56	0.2–0.1
Muscle > skin		1.4	0.52	2.70	0.02–0.01
15 minutes heat; 60 watts	10 + 10				
Subcutaneous > skin		0.7	0.40	1.74	0.1
Muscle > subcutaneous		1.4	0.37	3.78	0.01–0.001
Muscle > skin		2.1	0.32	6.56	<0.001
20 minutes heat; 60 watts	10 + 10				
Subcutaneous > skin		0.4	0.42	0.95	0.4–0.3
Muscle > subcutaneous		1.2	0.40	3.00	0.01–0.001
Muscle > skin		1.6	0.31	5.16	<0.001
30 minutes heat; 60 watts	10 + 10				
Subcutaneous > skin		0.3	0.33	0.91	0.4–0.3
Muscle > subcutaneous		1.4	0.38	3.68	0.01–0.001
Muscle > skin		1.7	0.32	5.30	<0.001

for 15 and 20 minutes are analyzed from a statistical standpoint in table 9. The changes of blood flow after exposure at 80 watts will be treated separately.

In charts 6 and 7 the change of blood flow in the exposed extremity (at 80 watts) is related to the duration of exposure. In chart 6*a* this change is expressed in cubic centimeters per minute, while in chart 7*a* it is expressed as a percentage increase. The curve forms are similar and are more or less

symmetrical and sigmoid. This type of function is known as a logistic function and may be represented by the following formula:

TABLE 6. — *Comparison of Temperature Rise of Skin, Subcutaneous Tissue and Muscle After Exposure to Microwaves at 80 Watts.*

Data Compared	Mean Difference °C*	Standard Error, °C.	t	P
Muscle > subcutaneous	0.5	0.20	2.50	0.05-0.02
Subcutaneous > skin	0.7	0.11	6.36	<0.001

* Mean of average difference in rise of temperature after 80 watt exposure for one, five, ten, fifteen, twenty, twenty-five and thirty minutes.

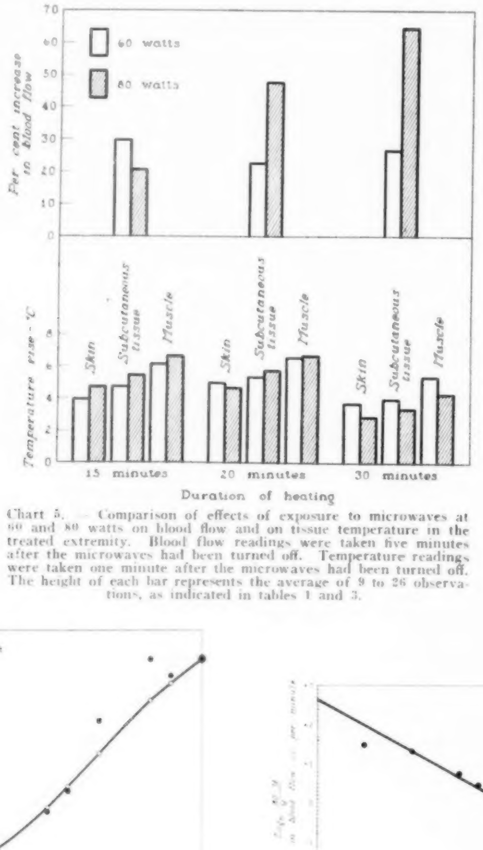
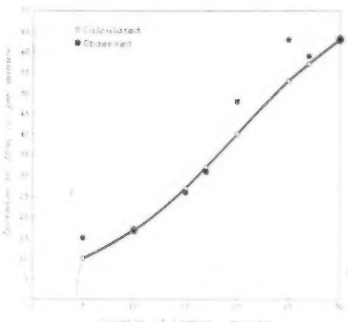
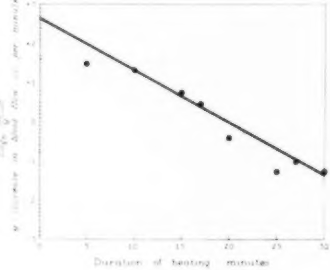


Chart 5. — Comparison of effects of exposure to microwaves at 60 and 80 watts on blood flow and on tissue temperature in the treated extremity. Blood flow readings were taken five minutes after the microwaves had been turned off. Temperature readings were taken one minute after the microwaves had been turned off. The height of each bar represents the average of 9 to 26 observations, as indicated in tables 1 and 3.



6a



6b

Chart 6. — Effect of exposure to microwaves (80 watts) on blood flow in the treated extremity. In *a* the ordinate indicates the increase of flow in cubic centimeters per minute, while in *b* the ordinate indicates a logarithmic function of the increase of flow in cubic centimeters per minute. Blood flow readings were taken five minutes after the microwaves had been turned off. Each observed point in figure 6*a* is the average of 9 to 20 observations.

TABLE 7. — *Comparison of Effect on Tissue Temperature of Exposure to Microwaves at 60 and at 80 Watts.*

Data Compared	Observations	Difference Between Means, °C.	Standard Error, °C.	*t*	*P*
15 minutes heat	10 + 10				
60 and 80 watts					
Skin (80 >60)		0.7	0.63	1.11	0.3–0.2
Subcutaneous (80 >60)		0.7	0.82	0.85	0.5–0.4
Muscle (80 >60)		0.5	0.45	1.11	0.3–0.2
20 minutes heat	10 + 25				
60 and 80 watts					
Skin (60 >80)		0.3	0.41	0.73	0.5–0.4
Subcutaneous (80 >60)		0.4	0.50	0.80	0.5–0.4
Muscle (80 >60)		0.1	0.40	0.25	0.8
30 minutes heat	10 + 10				
60 and 80 watts					
Skin (60 >80)		0.8	0.37	2.16	0.05
Subcutaneous (60 >80)		0.6	0.50	1.20	0.3–0.2
Muscle (60 >80)		1.1	0.48	2.29	0.05–0.02

TABLE 8. — *Comparison of Effect of Exposure to Microwaves at 60 and at 80 Watts on Blood Flow.*

Data Compared	Observations	Difference Between Means, Cc. Per 100 Cc.	Standard Error, Cc. Per 100 Cc.	t	P
15 minutes heat (60 >80)	9 + 10	0.8	0.70	1.14	0.3–0.2
20 minutes heat (80 >60)	13 + 20	1.8	0.73	2.46	0.02
30 minutes heat (80 >60)	10 + 12	2.6	1.10	2.36	0.05–0.02

$$y = \frac{K}{1 + Ce^{rt}}$$

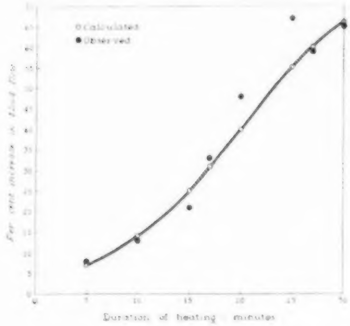
where y is the dependent variable (increase of blood flow),
t is the independent variable (duration of exposure),
K is the distance between the two asymptotic values of y.
If the lower asymptote is at $y = O$, then K represents the value of the upper asymptote.
r is a parameter associated with the rate of the reaction, and
C is a constant of integration.

The value of the parameters may be determined graphically by plotting $\log \frac{K-y}{y}$ against the duration of exposure. Various values for K are chosen and a curve is plotted for each value of K. That value of K is chosen which gives a linear relationship which fits the experimentally determined points most closely. The line thus obtained can be used to obtain the parameters r and C. The lines fitting the data obtained in this study most closely are shown in charts *6b* and *7b* The equations which result are the following:

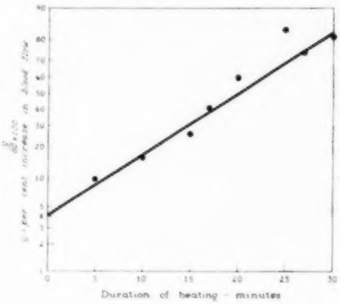
$$y = \frac{80}{1 + 14.3e^{-0.133t}}$$ (where y is the increase of blood flow in cubic centimeters per minute)

$$y = \frac{80}{1 + 23.1e^{-0.158t}}$$ (where y is the increase of blood flow in per cent)

The theoretical curves obtained from these equations are compared with the experimentally determined points in charts *6a* and *7a*. It is to be noted that the greatest discrepancy occurs at time equal to twenty-five minutes. At this point there was one unusually high value. The point which would be



7a



7b

Chart 7. — Effect of exposure to microwaves (80 watts) on blood flow in the treated extremity. In *a* the ordinate indicates the increase of flow in per cent, while in *b* the ordinate indicates a function of the percentage increase of flow. Blood flow readings were taken five minutes after the microwaves had been turned off. Each observed point in figure 7*a* is the average of 9 to 20 observations.

obtained with this value omitted would be much closer to the theoretical value.

This equation may be interpreted in the following manner. At time equal to plus infinity, the blood flow approaches an asymptote of 80 cc. per

TABLE 9. — *Comparison of Effects of Different Durations of Exposure to Microwaves on Blood Flow and on Tissue Temperature.*

Data Compared	Observations	Difference Between Means	Standard Error	*t*	*P*
60 watts—15 & 20 minutes heat (15 > 20)	10 + 13	0.99 cc. per 100 cc.	0.80 cc. per 100 cc.	1.24	0.3–0.2
80 watts— 5 & 20 minutes heat	25 + 26				
Skin (20 > 5)		0.2° C.	0.39° C.	0.52	0.6
Subcutaneous (20 > 5)		0.6	0.45	1.35	0.2–0.1
Muscle (20 > 5)		1.2	0.42	2.86	0.01–0.001
80 watts—20 & 25 minutes heat	25 + 10				
Skin (20 > 25)		0.4° C.	0.41° C.	0.98	0.4–0.3
Subcutaneous (20 > 25)		0.8	0.42	1.91	0.1–0.05
Muscle (20 > 25)		1.4	0.44	3.18	0.01–0.001
80 watts—25 & 30 minutes heat	10 + 10				
Skin (25 > 30)		1.4° C.	0.40° C.	3.50	0.01–0.001
Subcutaneous (25 > 30)		1.6	0.45	3.56	0.01–0.001
Muscle (25 > 30)		1.0	0.49	2.04	0.1–0.05
60 watts—15 & 20 minutes heat	10 + 10				
Skin (20 > 15)		0.9° C.	0.35° C.	2.58	0.02
Subcutaneous (20 > 15)		0.6	0.47	1.27	0.3–0.2
Muscle (20 > 15)		0.4	0.28	1.43	0.2–0.1
60 watts—20 & 30 minutes heat	10 + 10				
Skin (20 > 30)		1.3 °C	0.31° C.	4.20	<0.001
Subcutaneous (20 > 30)		1.4	0.44	3.18	0.01–0.001
Muscle (20 > 30)		1.2	0.33	3.64	0.01–0.001

minute increase of blood flow, or 80 per cent increase of blood flow. An inflection point in the curve is present at $K/2$. At this point, which occurs after twenty minutes of heating, the increase in cubic centimeters per minute or in percentage is 40. The slope of the curve is maximal at this point, which is the point of symmetry. Before this point is reached the curve is concave up, whereas beyond this point it is convex up.

General Observations

No harmful effects were noted in any of the subjects. Minimal cutaneous erythema was present in some subjects who had fair skins. This erythema disappeared in all cases within one hour after the termination of the exposure to microwaves. The only sensations noted were those of local and general warmth. While heating with an output of 80 watts, it was noted that the subjective feeling of warmth decreased at some time during the period of exposure to microwaves. In 6 subjects who were exposed for twenty minutes or longer this sensation of decrease of local temperature appeared between thirteen and twenty minutes after the beginning of exposure to microwaves. Of 18 subjects who were exposed to microwaves for fifteen minutes, only 2 noted any subjective local cooling. This occurred at nine and ten minutes after exposure to microwaves had been started.

Comment

The amount of energy absorbed by muscle after exposure to microwaves is greater than that absorbed by subcutaneous tissue or skin, as indicated by the greater rises of temperature occurring in muscular tissue one minute after the microwaves had been turned off. The rise of temperature alone does not indicate the disparity of energy absorption between muscle and subcutaneous tissue. If the specific heats of these two tissues are taken into consideration, the difference in the amount of energy absorbed becomes even greater. Muscle, with a higher specific heat (0.82) than subcutaneous tissue[10] (0.4-0.5) has a smaller rise of temperature than subcutaneous tissue for equal amounts of energy absorbed. This apparently greater effect of microwaves on muscular tissue than on subcutaneous tissue may be due to the fact that the conductivity of muscle is greater than that of fatty tissue.[11]

On comparing the findings at 60 and at 80 watts, certain observatons concerning the relation between energy output, peripheral blood flow and rise of temperature may be made. After fifteen minutes of exposure, the increases of blood flow are approximately the same for 60 and for 80 watts. The rise of temperature, however, is greater at the 80 watt output than at the 60 watt output, corresponding to the greater energy output of the former. After twenty minutes of exposure the tissue temperatures following 60 watts were greater than at fifteen minutes. With exposure at 80 watts, however, the temperatures of the tissues do not rise above the fifteen-minute level. Further increase of temperature has been prevented by the increase of blood flow at this time. After thirty minutes of exposure the increase of circulation is sufficient to remove heat from the tissues faster than it is accumulating, thus leading to a decline of tissue temperature from the twenty-minute level. The increase of blood flow was much greater at 80 watts than at 60 watts, and the fall of the temperature of the exposed tissues was correspondingly greater at 80 watts than at 60 watts.

10. DuBois, E. F.: Basal Metabolism in Health and Disease, ed. 3, Philadelphia, Lea & Febiger, 1936, pp. 69-70. Bürker, K.: In Tigerstedt, Robert: Handbuch der physiologischen Methodik, Leipzig, S. Hirzel, 1911, vol. 2, pt. 1, pp. 39-41. Rubner, Max: ibid. vol. 1, pp. 168-172.

11. Holmquest, H. J., and Marshall, J. G.: Brit. J. Phys. Med. **11**:70, 1936. Osborne, S. L., and Holmquest, H. J.: Technic of Electrotherapy and Its Physical and Physiological Basis, Springfield, Ill. Charles C Thomas, Publisher, 1944, pp. 483-485.

The fall of temperature of subcutaneous tissues during the second minute after the microwaves had been turned off is greater than that of muscle or skin. Subsequently, the decrease of temperature in the muscle is greater than in the subcutaneous tissue. The low specific heat of subcutaneous tissue may be a factor, for a relatively small amount of energy loss will result in a relatively great temperature decline. In addition, some of the factors responsible for the cooling of muscle may not be operating maximally immediately after completion of the exposure. Leden and her coworkers[6] found, in the dog, that the blood flow in the femoral vein usually did not reach its peak until some time after the microwaves had been turned off. Finally, continued production of heat within the muscle after exposure may alter its cooling pattern.

In this study the logistic curve was used to describe the increase of blood flow resulting from 80 watt exposure for various durations. The logistic curve has been used to describe growth of population[12] and of organisms,[13] data on bioassay[14] and autocatalytic reactions.[15] In the autocatalytic reaction the acceleration during the early phase is explained by the formation of a substance which is either a product or a by-product of the main reaction and which accelerates the reaction. The phase of retardation may be the result of exhaustion of the substrates of the reaction and the accumulation of the reaction products with acceleration of the reaction in the reverse direction. With this in mind, some suggestions may be offered to explain the acceleration and retardation phases in the increase of circulation resulting from exposure to microwaves. Heat may cause vasodilation by direct action or by action on vessels through the axon reflex.[6] The accelerative factor may be found in the metabolites which are formed within the tissues. As the temperatures within the tissues increase, the metabolism increases and the production of metabolites is enhanced. These metabolites aid in the dilation of the vessels. Two factors may be present which act to retard the circulatory increase. One is the presence of a maximal vascular bed. The other is the removal by the circulation of the factors which increase the blood flow — namely, heat and metabolites. Thus, as the circulation increases, it exerts a damping effect on further increase. It is to be noted that the retardation phase in the increase of blood flow and the decrease of tissue temperature occur at the same time.

If the "flushing action" of an increase of blood flow is desired for therapeutic purposes, exposure at 80 watts for thirty minutes may prove more desirable than exposure at 80 watts for twenty minutes and is also preferable to 60 watt exposure for any of the durations used in this study (this is true for the hemispherical director of 9 cm. diameter placed 5 cm. from the skin). The advantage of the 80 watt exposure for thirty minutes is indicated by the decrease of tissue temperature from its peak value at twenty minutes.

Summary

Two hundred and fifty-four observations were made on 50 normal human subjects concerning the effects of microwave radiations (2,450 megacycles per second) on the peripheral circulation and on the temperature of skin, subcutaneous tissue and muscle. The director used was hemispherical and about 9 cm. in diameter and was 5 cm. from the skin during the period of

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12. (*a*) Pearl, Raymond: Introduction to Medical Biometry and Statistics, ed. 3, Philadelphia, W. B. Saunders Company, 1940, pp. 459-470. (*b*) Thompson, D. W.: On Growth and Form, New York, The Macmillan Company, 1942, pp. 140-171, 255-261.
13. Robertson, T. B.: The Chemical Basis of Growth and Senescence. Philadelphia, J. B. Lippincott Company, 1923, pp. 1-16, 81-91, 138-150.
14. Berkson, Joseph: J. Am. Statist., A. **39**:357, 1944.
15. Reed, L. J., and Berkson, Joseph: J. Phys. Chem. **33**:760, 1929. Thompson.12b. Robertson.13.

exposure. The output used was 60 or 80 watts, and the duration of exposure varied from one to thirty minutes. The following observations could be made:

1. Significant increases of blood flow and of tissue temperature in the exposed extremity resulted with both outputs and all durations used. There were minimal general effects and no ill effects.

2. The greatest amount of energy absorbed was, on the average, in the muscle.

3. After absorption of energy reached a certain point, the increase of blood flow was sufficient to remove heat at a greater rate than it was accumulating, resulting in a fall of tissue temperature from the peak reached at twenty minutes of exposure. The greater the increase of circulation, the greater the decrease of the temperature of exposed tissues from the maximal values reached. After thirty minutes of exposure significantly greater increases of blood flow resulted from 80 watt exposure than from 60 watt exposure.

4. The curve relating increase of blood flow to duration of exposure at 80 watts is S shaped and indicates an early phase of acceleration of the increase of blood flow, followed by a phase of retardation.

We acknowledge with gratitude the helpful suggestions and guidance given by Dr. Berkson and Mr. Gage in the statistical analysis of the data.

Discussion

Dr. Stafford L. Osborne (Chicago): I think all of us who have been here this morning have really had an intellectual treat, not the least of which is the paper to which we have just listened. I should like to congratulate Dr. Gersten on his able presentation. The only thing I regret is that we have only a meager fifteen minutes to present such valuable and important data. Therefore, I am sure that some of the points which I shall bring up, when the work is in final published form, will have been answered.

The first question I should like to ask is about the statistical method which was used to determine the significance of these changes which occurred in temperature and blood flow.

Second, the essayist states that the average temperature rise was greater in muscle than in the subcutaneous tissues and the temperature rise was higher in the subcutaneous tissues than the rise on the surface of the skin. In other words, the heating gradient was reversed.

If this is actually true, then the microwave diathermy might very well be a dangerous method to use clinically, because dangerously high temperatures might be secured in the deeper structures with a tolerable surface temperature. Our own studies do not show this reversal of the heating gradient. I wonder (and it is pure conjecture) if these differences are not more apparent than real and due in large measure to differences in the technic used by the laboratories in taking the temperature readings. One certainly cannot question the results which are presented to us.

Third, I should like to know whether you found, Dr. Gersten, a good correlation between temperature rise and blood flow, if you worked out a correlation factor. Our own studies, which were presented this week, apparently do not show a good correlation factor.

The material was presented rapidly, and I had the good fortune to go over Dr. Gersten's paper, which he kindly sent me well in advance, so it was easy for me to sit down and listen. I am one of those individuals who have to get things by the eye; at least I get them much better by the eye than I do by ear, and so Dr. Gersten, I am sure, will be able to put me right if I misunderstood, or if he did not make the statements, or if it was not clear to me.

Dr. Gersten, I believe, stated that after fifteen minutes' exposure at 60 or 80 watts the blood flow is approximately the same, although there was a greater temperature increase at 80 watts. It was stated that with additional time exposure at 80 watts there was no further increase in temperature because of the increased blood flow. Yet it is stated that after twenty minutes' exposure at 60 watts there was an increase in the temperature rise.

I just wonder whether this is an error, or whether I have not read correctly. If I have read correctly, I am sure Dr. Gersten can clear up that slight apparent discrepancy.

Probably what I am going to say next is a little trite, but there are many of us who are using these things clinically; we are essentially a group of clinicians, and some of us in the laboratories are so familiar with certain terms that familiarity breeds contempt. So if the laboratory workers will pardon my presumption for once, I should like to raise this point.

It would seem wise, I think, in most of our papers, when we write them, to point out that the increased temperature and

blood flow are produced only — and Dr. Gersten, I think, brought that out fairly well — by the absorption of energy by the tissues, and that the output of a generator — we hear so much about the output, without realizing that it is only that energy which is absorbed that can produce an effect — does not bear a direct relationship.

I think I have played with high frequency currents quite a little bit, and I certainly would not be so bold as to presume that, because I had exposed one person to 60 watts' output, the next person whom I exposed to 60 watts' output would show the same absorption. There may be a better relationship than I know, but I rather doubt it.

Hence, one person may absorb as much energy at an output of 60 watts as another one would, let us say, at 80 watts.

Dr. William Bierman (New York): This work presented by Dr. Gersten is of great interest to those of us who have been working with the use of heating energies applied to the animal organism, particularly the human body, in that it corroborates again a fact which has been observed by many of us — namely, that at a certain period the temperature rise in tissues after the introduction of heating energies ceases. We have assumed that this was due to increased removal of heating energy by increased circulation.

Obviously, then, there is no absolute parallelism between temperature and circulation.

I was interested in observing the data presented this morning in that the rather abrupt change in temperature gradient occurs in these instances in about twenty minutes. With other forms of heating energy, including the so called short wave current, applications of radiant energy — and I think the method of heating is an incidental factor — we have observed a rather sharp alteration at periods of twelve minutes and fifteen minutes.

There obviously is some sort of a trigger mechanism, because the change is relatively abrupt, and I am wondering whether that trigger mechanism is not influenced by two things: the total amount of heating energies, the amount actually absorbed in the tissue, and also the abruptness of the rise. This is an attempt on the part of nature to protect tissue against thermal destruction. Obviously, if the localized tissue temperature continued to rise, it would reach a point where irreversible alterations would occur.

Dr. Ernst Fischer (Richmond, Va.): If I understood the speaker correctly, he concludes that the energy is absorbed at a greater rate by muscle tissue than by other tissues. That is a possibility, but is this conclusion not a little premature? There exists the theoretical possibility that, especially at the beginning of the microwave exposure, the increase in blood flow is restricted to the superficial tissue. This would produce a greater rate of heating of the limb by the blood flow independently from the absorption of energy by the muscles.

I might be wrong in my physics, but is there not the possibility that these waves are reflected backward from the bones, and a higher heating of the muscles produced in this way? If this is true, you cannot be sure that the muscle tissue itself has a higher absorption rate for microwaves than the other tissues.

Dr. Ludwig W. Eichna (New York): I am glad to see the tendency to talk about the changes which one measures. Here we have a demonstration of a difference in the changes of two associated measurements, temperature and blood flow, both considered at times to measure the same function.

The point I raise is as follows: If I understand correctly, the microwaves were directed toward the forearm. The temperature measurements were made in the area to which the energy was directed, the forearm. The blood flow, however, if I understood again correctly, is a summation of the effects which occurred within the forearm and hand, because this is a forearm plus hand plethysmograph. Therefore, the plethysmograph is measuring the blood flow contribution of an area which was subjected to the microwave energy, the forearm, plus an area which was not subjected to the microwave energy, the hand.

Therefore, one wonders whether the temperature measurements and the blood flow measurements can really be compared, because, after all, there are measurements, in the one case, of the area which received the energy — that is the temperature changes — and, in the other case, a summated effect of the area which received the energy and an area which did not receive the energy, the blood flow.

Dr. Louis B. Newman (Chicago): This paper on the heating and circulatory effects of microwaves was very interesting and informative. However, there are several questions that enter my mind.

Since the distance of the applicator from the tissues, the position of the patient, the room temperature and the frequency of the microwaves were kept constant during the experiments, I am wondering whether the beneficial effects would be enhanced if the distance of the applicator from the tissues were increased and the treatment time prolonged. Also, would these beneficial effects be further enhanced by exposing a greater volume of tissue to the effects of the microwaves?

It was observed by the authors that the temperature of the tissues dropped after approximately twenty minutes of treatment, while the blood flow increased. Would the temperature of the tissues continue to drop still further if the treatments were given for longer than twenty minutes?

Another question that I should like to ask is regarding the effects of microwaves on the temperature of the tissues, as well as circulation when markedly traumatized

tissues are exposed to these high frequency waves.

Dr. Gersten (closing): I do not know whether I can answer all the questions; I will try:

The statistical method which was used was the accepted one of determining the standard deviation, standard error and t value, and we accepted as significant any change in which the p value was 0.02 or smaller; 0.05 was accepted as borderline, and anything above that was insignificant.

We found that the normal preheating gradient was not changed by microwaves. The preheating temperature was, on the average, greatest in the muscle and least in the skin, and the final temperature also was greatest in the muscle. This was true for all durations and both outputs.

As far as burning is concerned, we found that the highest average temperature in the muscle was achieved after twenty minutes of exposure at 80 watts and that at this point it was 41.4 C. This did not approach the temperature at which normal tissues are burned.

The question of the correlation between increase in temperature and blood flow has been answered to a great degree by Dr. Bierman. I wish I could diagram here what we feel we have determined.

This sigmoid curve which was described today, and which has been called a logistic function, is typical of the autocatalytic reaction. If heat is one stimulus for an increase in blood flow, the autocatalytic reaction would require the presence of another factor which would enhance the reaction and, thus, cause an acceleration of the increase in blood flow. We feel that this catalyst is represented by metabolites in the tissue. As the temperature rises, the metabolism in the tissue increases, the production of metabolites increases, and we have an added factor which causes an increase in blood flow. Therefore, we can say that during this early period, the period up to twenty minutes, there is a direct relation between the energy output, the temperature rise and the increase in blood flow.

At this point, however, it seems that the increase in circulation is so great that the factors which are causing an increase in the flow — namely, the metabolites and the heat, are being removed at a greater rate than they are accumulating. Thus, even though the blood flow rises further, the temperature declines as a result of this increase in blood flow. Therefore, after this twenty-minute period we can say that the relationship between the increase in blood flow and the temperature is no longer a direct one but that, as the blood flow increases further, the temperature will decline more and more.

Dr. Fischer mentioned the rate of energy absorption. We did not want to mention the rate of absorption of energy; the only thing we could say was that the quantity of energy absorbed was greater in the muscle. The evidence for this lies not only in the greater rise in temperature of the muscle but also in the difference in specific heats between muscle and subcutaneous tissue. With subcutaneous tissue having a much smaller specific heat than muscle — for muscle it is 0.8 and for subcutaneous tissue about 0.5 — the amount of energy absorption by muscle is greater for an equivalent rise of temperature. For the explanation of this we feel that the conductivity of muscle is an important factor, for tissues of greater conductivity would absorb greater amounts of the electromagnetic radiation.

Dr. Eichna is right in saying that we have taken the flow of two areas, the hand and the forearm. We have tested the hypothesis in other experiments, and we have found that the increase in flow in cubic centimeters is approximately the same when we take the flow in the forearm alone or the combined flow of forearm and hand. As far as the percentages are concerned, the percentage change would be much greater if we took the flow in the forearm alone, but the cubic centimeter change would be approximately the same. We have plotted the data from the standpoint of cubic centimeters per minute increase and per cent increase of flow and found that the curve shapes were approximately the same.

Dr. Newman questioned what might occur with an increase in the distance of application. We are not quite certain. It is possible that the decrease in energy output, as with the 60 watt output, might be an example of what would happen if we used 80 watts at an increased distance. In other words, we got temperature rises which were approximately the same as with 80 watts but blood flow changes which were not as great. That may or may not have been the case had we increased the distance rather than decreased the output.

The effect on the other extremities was consistently insignificant. There were no increases or decreases of blood flow greater than 14 per cent.

THE BROADENING HORIZONS OF REHABILITATION AND PHYSICAL MEDICINE *

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Today, as medical science moves forward in the prevention and cure of infectious diseases, chronic illness, with its resultant physical disability, has become the nation's primary medical problem. Seventy-five years ago, chronic diseases caused one-fifteenth of all deaths. They are now responsible for as much as three-fourths.[1] Whereas diabetes ranked twenty-seventh and arteriosclerosis thirty-fourth as causes of death in 1900, they were eighth and tenth in 1944.[2] Added to this is the tremendous long term toll of chronic illness and disability. Acute, infectious disease usually results in rapid recovery or death, but chronic illness may linger for years; its social and economic costs cannot be measured by mortality tables alone.

One of the principal causes of the increasing prevalence of chronic disease has been the great advances in medical and surgical care that have prevented death and produced an aging population. Two thousand years ago, the average length of life was 25 years; at the turn of the century, it was 49; today, it is 66.[3] In 1900, one person in twenty-five was 65 years of age or older; it is estimated that in 1980, the ratio will be one in ten.[4]

As people become older, their medical needs change and they demand more medical service. In 1940, the 26.5 per cent of the nation's population over 45 required over half the nation's medical services.[5] By 1980, it is estimated that the number of persons over 45 will constitute nearly half of the population.[4]

As chronic disease is usually nonreportable, reliable statistics as to its extent are difficult to find. Most currently used figures spring from the National Health Survey conducted by the United States Public Health Service in 1935, in which 3,000,000 persons in 83 cities and 23 rural areas were surveyed. In that study, it was found that there were approximately 23,000,000 persons handicapped to some extent by disease, accident, maladjustment or former wars.[6] Such a figure seems staggering at first, but its authenticity seems logical when it is remembered that approximately one veteran out of every eight who served in World War II is now receiving compensation for a service-incurred disability.[7] Such disabilities are not readily apparent in many veterans, nor are they apparent in many of the 23,000,000 civilians.

Later reports, based on smaller samplings, have indicated that chronic

* Read at the Twenty-Sixth Annual Session of the American Congress of Physical Medicine, Washington, D. C., Sept. 8, 1948.

1. A Program for the Care of the Chronically Ill in New York State: The Report of the New York State Commission to Formulate a Long Range Health Program, Leg. Doc. No. 69 (1947), Albany, N. Y., Williams Press, 1947, p. 20.
2. Crampton, C. Ward: What Geriatrics Means to the Medical Profession, New York Med. **3**:10 (May 20) 1947.
3. Whelpton, P. K.: Forecasts of the Population of the United States, 1947-1948. Data taken from Table 33 "Population by Broad Age Groups, for the Unites States, 1900, and Forecasts, 1950 to 1975." Washington, D. C., Department of Commerce, Bureau of the Census, 1947.
4. Whelpton,[3] table 33.
5. Crampton,[2] p. 10.
6. Karpinos, Bernard D.: The Physically Handicapped, Pub. Health Rep. **58**:573 (Oct. 22) 1943.
7. Administrator of Veterans Affairs: Annual Report for the Fiscal Year Ending June 30, 1947, Washington, D. C., Government Printing Office, 1948, p. 19.

disease is even more prevalent than the National Health Survey pointed out. In a recent survey in New Haven, Conn., conducted by the School of Public Health of Yale University, it was found that 121 persons for each 1,000 population suffered from chronic illness and that one-third of this number were totally disabled.[8]

Lacking specific measures for the cure of many of the diseases which produce this tremendous load of disability, medicine must look to rehabilitation and physical medicine for the ". . . restoration of the handicapped to the fullest physical, mental, social, vocational and economic usefulness of which they are capable."[9]

The physician has always been interested in the total welfare of his patient. Prior to World War II, however, the great majority of the medical profession looked upon rehabilitation as an extracurricular activity of medicine, something dealing with social work and vocational training, but which had little concern or which held but few implications for medicine. Today, that trend is being reversed, and although there are still many physicians who are unfamiliar with the aims and procedures of rehabilitation — in 1946 only 3 per cent of the new cases referred to state rehabilitation agencies and commissions for the blind were from physicians[10] — more and more, medicine is beginning to recognize that medical care cannot be considered complete until the patient has been trained "to live and work with what he has left."

One of the most promising developments in recent years is the increasing attention which medical schools are now giving to this concept of total care. In response to a questionnaire sent out by the Baruch Committee on Physical Medicine in November, 1943, 30 of the 65 schools queried replied that physical medicine instruction was given to medical students and interns. Dr. Sidney Licht has recently reported that a similar survey, made in late 1947, indicated that the number had increased to 60.[11]

One of the first schools to teach rehabilitation and physical medicine as the "third phase of medicine," is New York University, where a Department of Rehabilitation and Physical Medicine has been in existence for two years as a major department of the college. Major activities of the department are training, research and patient care, through the use of the teaching facilities of the College of Medicine, the rehabilitation and physical medicine service at Bellevue Hospital, and the Institute of Rehabilitation and Physical Medicnie of the New York University-Bellevue Medical Center.

Undergraduate training during this past year has consisted of a one hour indoctrination lecture in their first year, four hours of lecture-demonstration on the relationship of medical rehabilitation and physical medicine to general medicine in the second year, six hours of lecture-demonstrations on electrotherapy, hydrotherapy, muscle reeducation, manual muscle testing, therapeutic exercises and the use of other physical agents in diagnosis and treatment, and twenty-two hours of classes consisting of lectures, demonstrations, films and field strips on medical, social, economic and vocational aspects of rehabilitation, the technic of physical medicine and the therapy of the third phase of medicine.

Clinical clerkships of three months in the third year and two months in the fourth year consist of orientation in the uses of the physical modalities

8. Study Plan for Committee on Chronic Disease (mimeographed), New Haven, Conn.: New Haven Council of Social Agencies, 1948, p. 2.
9. Definition of "Rehabilitation" Adopted by the National Council on Rehabilitation, August, 1943.
10. Federal Security Agency, Office of Vocational Rehabilitation: The Doctor and Vocational Rehabilitation for Civilians, Washington, D. C., Government Printing Office, 1947, p. 11.
11. Annual Report of the Baruch Committee on Physical Medicine for the Period of January 1, 1947, to December 31, 1947, New York, The Baruch Committee, 1948, p. 6.

in the evaluation and treatment of physical, psychosocial and vocational rehabilitation. A twelve or twenty-four weeks' course is offered in the postgraduate division, consisting of theoretical and practical training in the uses of the physical agents, in the evaluation and treatment of physical disabilities by physical, psychosocial and vocational rehabilitation and the therapy of the third phase of medicine.

The department also cooperates with the New York University School of Education in giving didactic instruction and clinical training to physical therapists, occupational therapists, psychologists, physical educators, teachers of the handicapped, rehabilitation administrators, vocational guidance specialists and other students concerned with rehabilitation and services to the handicapped and with the Bellevue School of Nursing. A number of other schools are revising their curricula in accordance with these newer concepts.

With the growing incidence of disability due to chronic disease, rehabilitation and physical medicine must assume a great deal of the leadership in the responsibility of society which Dr. Edward L. Bortz so aptly summarized when he said: "The society which fosters research to save human life cannot escape the responsibility for the life thus extended. It is for science not only to add years to life, but, more important, to add life to the years." This is the challenge which faces the broadening horizons of rehabilitation and physical medicine.

Discussion

Dr. George Morris Piersol (Philadelphia): Dr. Rusk has emphasized once more the changing age trend in our population, with its attendant increase in chronic degenerative diseases. The effective care of persons suffering from such diseases will place an ever increasing load upon physical medicine.

The Federal Security Administrator recently estimated that 250,000 men and women annually become disabled through illness or injury in this country. It is stated that the majority of this group can be restored to some degree of normal living, provided sufficient medical and nonmedical personnel can be made available for the task of rehabilitation. At present, lack of trained personnel is the most serious obstacle to an adequate restoration service. To date, the recruitment and training of nonmedical groups has been accomplished with a reasonable degree of success.

As Dr. Rusk has implied, the most serious aspect of the problem is the lack of physicians, properly trained in physical medicine, to direct the growing ranks of physical and occupational therapists.

The solution of this difficulty is to educate more doctors in this particular field. The constructive approach to the problem of training doctors in physical medicine must be made in our medical schools and among the younger physicians. Although this is being done to a greater extent than ever before, still much remains to be accomplished.

Some educators insist that physical medicine is not an undergraduate activity but belongs in the graduate field. Nevertheless, graduate physicians are slow to take up physical medicine as a specialty because too many still fail to appreciate the value of adequate physical medicine to the people of this country.

To overcome this attitude is a task to which those interested in physiatry should dedicate themselves. The time has now come to supplant propagandizing general talks by effective demonstrations, to our colleagues and the lay public, of what physical medicine can actually accomplish in the rehabilitation of the chronicallly sick and disabled.

It has been clearly shown that the cornerstone of any reconditioning program is physical medicine interpreted in its broadest sense. Here lies the great future and opportunity of physical medicine. It is the one field which offers a form of treatment which can be carried out only by a specially trained personnel, which aims particularly at restoring productive independence and self esteem in those who are incapacitated and who, otherwise, would become a burden and a charge upon their families or the community.

Future development of physical medicine and its justification as a definite specialty rests not so much upon devising technics to relieve symptoms, which in the past has been too often the case, as upon our ability to prove its worth as the most important therapeutic factor in the ever expanding national rehabilitation program.

THE CUTANEOUS ABSORPTION OF RADON FROM NATURALLY CARBONATED MINERAL WATER AND PLAIN WATER BATHS *

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Introduction

Waters containing radioactive substances have been used at spas for centuries in the treatment of many patients suffering from rheumatic diseases. They have been administered by ingestion, inhalation and baths. The active substance, radon, is a gas and is the emanation from radium. In some waters both radium salts and radon are found whereas in others only radon is present.

Physiologic studies of the way in which radon is utilized have indicated that it is absorbed from radon-containing waters through the skin when the patient is in the bath. The studies reported here were made to determine additional information regarding this mechanism of absorption. They demonstrated that radon is absorbed from both plain water and naturally carbonated mineral water.

Literature

Kûhnau, in Vogt's review of balneology,[1] has cited the work of various authors who have found that the expired air showed an appreciable increase in radon content when the subject bathed in radon-containing waters. Markl,[2] Santholzer[3] and Lang[4] reported observations for plain water. Janitzky and associates[5] studied this problem with the mineral waters of Oberschlema, Germany, and Mougeot and Aubertot,[6] with the waters of Royat, France.

As reported by Kûhnau,[1] Janitzky found that the absorption of radon from the bath was greater by five times when the temperature of the bath was 38 C. than occurred with a bath at 31 C. containing the same concentration of radon. He also reported that the absorption was less with increasing age. Fresenius and Dick[7] observed that the absorption was greater with carbon dioxide containing water than with water free of carbon dioxide. This article by Kûhnau contains further details of studies dealing with absorption of radon through the skin.

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* From the Medical Department of The Saratoga Spa.

* The apparatus with radium pellets was loaned for these studies by the Canadian Radium & Uranium Corporation, New York, who also supported this work, in part, with a grant.

* Read at the Twenty-Sixth Annual Session of the American Congress of Physical Medicine, Washington, D. C., Sept. 9, 1948.

1. Kûhnau, J.: Radioactive Quellen, in Vogt, H.: Lehrbuch der Bäder- und Klimaheilkunde, J. Springer. Berlin 1940, 555-586.
2. Markl, J.: Radiumemanation and Organismus; Ueber die Aufnahme von Radium manation beim radioaktiven Heilbade in den Organismus, Strahlentherapie 49:92, 1934.
3. Santholzer, W.: Versuch zur Lösung der Frage der Permeabilität der Haut für Radiumemanation, Strahlentherapie 48:519, 1933.
4. Lang, G.: Ueber die Permeabilität der menschlichen Haut für Radiumemanation im Luftbad, Strahlentherapie 52:187, 1935.
5. Janizky, A.; Raschig, W., Steinke, O., and Wichman, W.: Untersuchungen ueber die Frage ob Radiumemanation durch die Haut des menschlichen Körpers Lindurchgeht, Klin. Wchnschr. 12:1692, 1933.
6. Mougeot, A., and Aubertot, V.: Les échanges gazeaux au cours des bains thermaux de Royat, Bull. Acad. de méd., Paris 110:27, 1933.
7. Fresenius, L., and Dick, W.: Ueber den Einfluss der Kohlensâure auf den Durchtritt der Emanation durch die Haut in emanationshaltigen Bädern, Balneologe 2:529, 1935.

Lange and Evans[8] have reported the absorption of radon through the skin and its exhalation through the lungs by means of local application of the ointments containing about 49 microcuries of radon per gram of hydrous wool fat (Lanolin). The thickness of application varied between 2 and 3 mm. on the skin. Exhaled air was collected after twenty minutes, two and two-thirds hours and four and one-half hours. They found that approximately 2.4 per cent of the radon applied was exhaled within the first four and one-half hours when the ointment was applied to a leg ulcer, whereas the amounts absorbed in the same circumstance from normal skin and exhaled were only 0.13 per cent and 0.08 per cent for the same period.

Lange[9] again reported that radon ointment containing 80 microcuries was applied to the skin of 9 persons one to four times at an interval of three days. Each application was kept on for twenty-four hours under the air-tight dressing, and patients were observed by means of fluorescein tests once a week for a period up to five weeks after the last exposure. It is found that the skin temperature might or might not be slightly elevated. The fluorescein test showed a marked increase in vascularity of the area and a still greater increase in capillary permeability. These changes might persist up to four weeks after a single application, although there was no noticeable reddening of the skin. If the application was repeated four times in succession at intervals of three days, the changes became more pronounced. The permeability of the blood vessels in the exposed area was increased up to 230 per cent above normal as measured with the Dermofluorometer, a photoelectric skin fluorescence meter. The skin temperature increased up to 3 degrees (F.), indicating a marked hypervascularity.

Methods of Study

Two men were observed in a series of five observations, each under different conditions. Each subject was studied in plain water to which was added a known amount of radioactive water, and in the naturally carbonated mineral water of the Spa, to which was added the same amount of radioactive water as was used in the plain water. Also, each subject was observed while breathing air over the water and while breathing outside air (free from radon emanation) through a mask.

The radioactive water containing the added radon was prepared in special cylindrical metallic containers in which a known volume of water (475 cc.) was exposed to a measured amount of radium for a period of twenty-four hours. The container had a filling chamber at the top with an overflow that permitted complete filling and prevented the entrapment of air bubbles. The radium was contained in paraffin-covered pellets and suspended in the water chamber in an enclosed screen jacket. In this way no radium could pass from the pellet into the water. Some containers had a sufficient number of pellets to produce 35 to 40 microcuries of radon in a period of twenty-four hours, and others had a larger number of pellets producing 64 to 72 microcuries. For the observations reported here, water containing 64 microcuries of radon was added to each bath to provide the radon for study. The concentration of radon in bath water, which in volume amounted to 600 liters, was 0.107 microcuries per liter. In order to avoid loss of radon from the prepared radioactive water, it was transferred from the container directly into the bath by special valve and attached rubber tube. This procedure assured us that the full amount of radon actually was placed in the water of the bath.

8. Lange, K., and Evans, R. D.: Absorption of Radon Through the Skin and Its Exhalation Through the Lungs, Radiology 48:514, 1947.
9. Lange, K.: The Physical and Physiologic Basis of Alpha Ray Therapy, Proc. Rudolf Virchow M. Soc. 4:42, 1945.

The bathtub was covered except for a small opening near the subject's head. This prevented excessive loss of radon from the surface of the water into the air of the room. It also provided a greater concentration of radon in the air breathed when the subject did not wear a mask.

Samples of expired air were collected in rubber bags and transferred to vacuum flasks of two liter capacity, which were provided by the United States Bureau of Standards. The duration of the bath was thirty minutes, and the bath temperature was 35 C. (95 F.) in all observations. The bathtub and apparatus for providing outside air was the same as that used by McClellan, Lessler and Doulin[10] for studying the cutaneous absorption of carbon dioxide.

Samples of expired air were collected at the end of 10, 20 and 30 minute periods while the patient was in the bath and at the end of one and two hours after the bath while he was resting in a separate room. Samples of the air of the bath room and the rest room were also collected. All samples were accurately labeled and forwarded promptly to the Bureau of Standards, Washington, D. C., by railway express. The analyses of these samples for radon concentration were made at the laboratories of the Bureau by their standard methods.

As a control, each subject was observed in the naturally carbonated water without added radon.

Experimental Data

1. *Radon Content of Outside and Room Air.* — The data of radon in air samples taken under various conditions are presented in table 1.

The air samples in the experimental room were taken from the area over an opening in the cover over the bath. They show the radon content of the inhaled air. The two samples in connection with the carbon dioxide water bath were made without the addition of any radon to the bath.

The outside air samples were taken through a connection to the air line conveying the air from outside the building to the subject wearing a mask and thus breathing air which was free from any radon emanation from the water of the bath. Any reason to explain the greater amount of radon in the outside air when the 2 subjects were in carbon dioxide water with radon than was found when they were in plain water is not evident.

The rest room air samples were collected at the midperiod of resting in a room which was some distance from the experimental bath room. The variation in these samples is not large and was probably influenced somewhat by the elimination of radon in the expired air of the subject during his rest period of two hours.

2. *Radon Content of Expired Air Collected from Subjects During the Bath and Subsequent Rest Periods.* — Data showing the amount of radon in the samples of expired air with each type of bath are included in table 2. These data have not been corrected for radon content of inspired air, as the purpose of this study was to determine the absorption of radon through the skin. By use of outside air it was possible to eliminate the effects of the radon in air over the tub. During the resting period the subject breathed the air of the rest room, which in nearly all observations contained only small amounts of radon.

A review of the material included in this table shows the variation in the output of radon in expired air during the different types of baths. The concentration of radon is specified by the negative exponent of the multiply-

10. McClellan, W. S.; Lessler, M. A., and Doulin, A. T.: Physiologic Effects of Carbon Dioxide Water Baths on Alveolar Carbon Dioxide Tension, Skin Temperature, and Respiratory Metabolism, Am. Heart J. 29:44, 1945.

TABLE 1. — *Curies of Radon Content Per Liter of Room Air and Outside Air Samples.*

Date	Subject	Experimental Room Over Tub	Outside Air	Rest Room	Type of Bath
12/ 3/45	M	1.03×10^{-12}	....	1.03×10^{-12}	CO_2
12/20/45	M	2.74×10^{-10}	....	5.39×10^{-11}	CO_2 + Rn
1/ 9/46	M	....	1.77×10^{-11}	0.38×10^{-12}	CO_2 + Rn + outside air
1/15/46	M	2.08×10^{-10}	....	7.12×10^{-12}	Plain H_2O + Rn
2/ 5/46	M	....	0.62×10^{-12}	1.00×10^{-12}	Plain H_2O + Rn + outside air
1/29/46	C	4.15×10^{-12}	....	2.42×10^{-12}	CO_2
2/ 7/46	C	3.53×10^{-10}	....	6.70×10^{-12}	CO_2 + Rn
2/14/46	C	....	2.89×10^{-11}	6.99×10^{-12}	CO_2 + Rn + outside air
2/21/46	C	9.34×10^{-11}	....	2.64×10^{-11}	Plain H_2O + Rn
2/28/46	C	....	0.17×10^{-12}	8.26×10^{-12}	Plain H_2O + Rn + outside air

ing factor, the greater amount being indicated by the smaller negative exponent. It is difficult to compare the data of the observed radon concentrations unless they are reduced to a common factor. For example, the value of 1.41×10^{-9} is the same as 141.0×10^{-11}. This gives the reader some indication of the variation of concentrations which occurred in the studies made.

For a clearer comparison of the findings the data recorded for each subject are presented in the chart. From the chart it is evident that the concentration of radon in the expired air is somewhat greater when the patient is bathing in carbon dioxide water containing radon than when he bathes in plain water with the same amount of radon. Also the concentration of radon in the expired air is greater when the subject breathes the air over the water in the tub than when he breathes air conducted by pipeline from outside the building. The data revealed an increasing concentration during the thirty minutes in the bath except for curve 1, subject M, where the great-

TABLE 2. — *Curies of Radon Per Liter of Expired Air During and After Baths.*

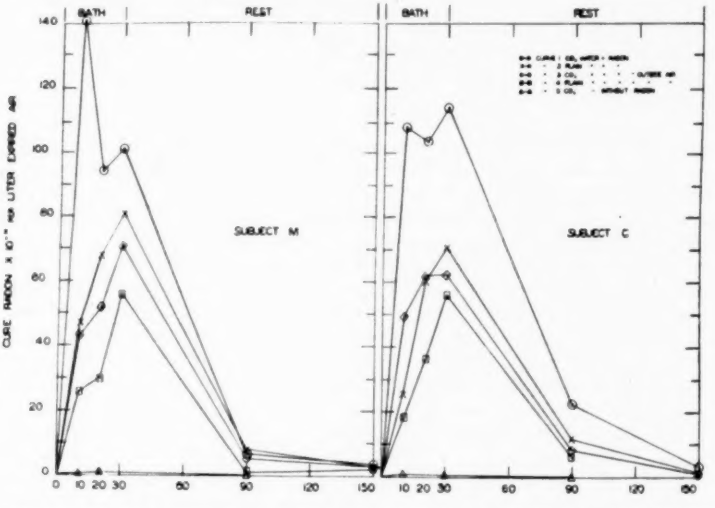
Type of Bath	During Bath			After Bath		
	10 Min.	20 Min.	30 Min.	1 Hr.	2 Hr.	3 Hr.
CO_2 bath Breathing room air						
12/ 3/45	1.72×10^{-12}	1.89×10^{-12}	....	1.05×10^{-12}	....	....
1/29/46	7.25×10^{-12}	*	2.79×10^{-12}	3.21×10^{-12}	1.17×10^{-12}	....
CO_2 + Rn Breathing room air						
12/20/45	1.41×10^{-9}	0.94×10^{-9}	1.01×10^{-9}	6.46×10^{-11}	3.18×10^{-11}	2.07×10^{-11}
2/ 7/46	1.09×10^{-9}	1.05×10^{-9}	1.14×10^{-9}	2.35×10^{-10}	3.69×10^{-11}	....
CO_2 + Rn Breathing outside air						
1/ 9/46	4.33×10^{-10}	5.15×10^{-10}	7.09×10^{-10}	5.01×10^{-11}	2.41×10^{-11}	....
2/14/46	5.02×10^{-10}	6.39×10^{-10}	6.40×10^{-10}	9.23×10^{-11}	1.89×10^{-11}	....
H_2O + Rn Breathing room air						
1/15/46	4.69×10^{-10}	6.80×10^{-10}	8.10×10^{-10}	7.96×10^{-11}	2.80×10^{-11}	....
2/21/46	2.66×10^{-10}	6.07×10^{-10}	7.14×10^{-10}	1.25×10^{-10}	2.03×10^{-11}	....
H_2O + Rn Breathing outside air						
2/ 5/46	2.48×10^{-10}	2.98×10^{-10}	5.59×10^{-10}	1.62×10^{-11}	2.10×10^{-11}	....
2/28/46	1.87×10^{-10}	3.62×10^{-10}	5.66×10^{-10}	7.70×10^{-11}	*	....

* Sample lost owing to insufficient vacuum in sampling flask.

est concentration was found in the ten minute sample. Only slight differences were noted in the comparable curves for the 2 subjects. Subject M apparently eliminated the radon faster than subject C, as indicated by the definitely lower values at the end of one hour after the bath.

Comment

The observations presented herewith were made to study the penetration of radon through the skin in baths containing this gas. The data obtained for the 2 subjects studied indicate without question that the radon does penetrate the skin and, in addition, that the amount of radon in the expired air during and after the baths is influenced also by the concentration of radon in the air breathed in during the observation.



The curves show the concentration of radon in the expired air of 2 subjects who used various types of baths as illustrated in the key. All data are reduced to the common factor of curies of radon $\times 10^{-11}$ per liter of expired air. The highest values for each subject (curve 1) were obtained when they bathed in carbon dioxide water with added radon and breathed the air over the tub.

1. *Does Radon Penetrate Through the Skin?* — The data presented in the tables and chart, particularly in the observations when the subjects were breathing outdoor air, leave no doubt that radon has entered the body, because the output of radon in expired air was two to three hundred times that noted in the expired air of the subject in the carbon dioxide bath without added radon. It appears that the absorption continues during the bath period for the concentration reaches its highest level after thirty minutes in the bath.

From the studies of MacKee, Sulzberger and others[11] with a substance which could be detected in the skin or subcutaneous tissue, it was concluded that substances dissolved in aqueous mediums are better absorbed than those applied to the skin in ointments. These authors also showed in some carefully prepared specimens that the concentration of these absorbed substances appears to be in and about the hair follicles, sebaceous cysts and possibly somewhat about the sweat glands. They also pointed out that there is an area in and just underneath the epidermis where the concentration of absorbed substances is less. Hence they expressed the belief that the penetra-

11. MacKee, G. M.; Sulzberger, M. B.; Herrmann, F., and Baer, R. L.: Histologic Studies on Percutaneous Penetration with Special Reference to the Effect of Vehicles, J. Invest. Dermat. 6:43, 1945.

tion of the skin, therefore, is largely through the anatomic channels connecting with the outside rather than directly through the stratified epithelium.

In experiments with carbon dioxide, Groedel and Wachter[12] have shown that the absorption is greater if the carbon dioxide is dissolved in water than if the subject is exposed to dry carbon dioxide gas.

2. *Does Carbon Dioxide in the Water Increase the Absorption of Radon?*— As is indicated in the curves of the chart, the curve for the expired air of patients in the carbon dioxide bath breathing outside air, as compared with that for the same patient in plain water with radon, shows approximately 65 per cent greater output with the patient in the carbon dioxide bath. During the resting period following these observations, the increased output following the carbon dioxide bath was evident, particularly during the first hour, but was not so pronounced during the second hour. When similar data were compared with the data for subjects breathing air over the tub, the increased output was approximately 87 per cent greater during the bath period, while during one hour following the bath the differences were not proportionately as great.

These data, therefore, support the thesis that carbon dioxide, which is also absorbed through the skin from the bath water, may act as a vehicle to increase the absorption of radon. It is also possible that the hyperemia in the skin resulting from the carbon dioxide may be the factor which accounts for the greater radon absorption. Regardless of the cause, the fact remains that more radon passes through the skin from carbon dioxide water than from plain water. There were considerable differences in the 2 subjects studied, but the size of this series is too small for general conclusions regarding the quantitative differences which may result in this problem.

3. *How Rapidly Is Radon Eliminated from the Body?* — The data obtained from study of the concentration of the expired air during the period after the bath indicate that the concentration of radon in the expired air drops rather rapidly during the first hour after the bath and then decreases less rapidly during the second and possibly the third hour. Owing to the complexity of obtaining and shipping samples, the experiments in only one instance were carried as long as three hours after the bath. In this case the concentration in expired air was only one-seventieth that of the maximum obtained during the bath. It would indicate that radon is freely eliminated from the body and in no sense results in a serious problem from the standpoint of accumulated radioactive substances in the body which might be deposited and later be detrimental.

An effort was made in the study of the expired air following the bath to have the patient in a separate part of the building where the air of the rest room would not be influenced by the radon escaping from the experimental bath. There is considerable variation in the figures for these periods, but all would indicate, as is shown in the chart, that elimination is nearly complete at the end of two to three hours.

4. *Clinical Observations.* — As a part of the study of radon baths, 30 patients who had various forms of arthritis were treated with a series of carbon dioxide baths to which the radon water was added. Each patient had a series of eighteen baths during a period of six weeks.

Many foreign observers have reported beneficial results from radon baths. In our series the radon content varied from 35 to 75 microcuries of radon in 200 liters of the natural carbon dioxide water, which is comparable to the strength of baths used in the European studies.

12. Groedel, F. M., and Wachter, R.: Ueber den Gasstoffwechsel in Süsswasser-, Salz-, Luft- und kohlensäuren Wasser- und Gasbad, Veröffentlichungen der Zentralstelle für Balneologie (Neue Folge) No. 16, 1929.

No reaction was noted in our series to indicate any harmful effect from the treatment. A number of the patients were relieved as indicated by a decrease in pain and swelling of the affected joints.

The analyses of the clinical records have not been completed; hence it is not possible to report the final results of this portion of the study.

Summary

1. Two subjects were studied under various conditions in baths of varying nature to determine the extent of radon absorption and elimination during and after the bath.

2. The concentration of radon in the expired air was greatest when the subject bathed in carbon dioxide water containing radon and breathed air over the surface of the tub. About the same amount of radon was eliminated by the subject in the carbon dioxide bath, breathing outside air, as occurred when the subject was in a plain water bath with radon, breathing air over the tub. The smallest elimination occurred when the patient was in a bath of plain water plus radon, breathing outside air.

3. From these data it appears

(*a*) That radon is absorbed through the skin.

(*b*) That radon is absorbed through the skin in greater amounts when added to water containing carbon dioxide as compared with the findings in plain water.

(*c*) That the inhaling of air containing radon increases the concentration of this element in the expired air.

(*d*) That the influence obtained from baths containing radon is due both to the absorption of radon through the skin and the inhalation of radon from air over the tub.

(*e*) That elimination of radon is rapid and nearly complete in three hours.

4. The data are not sufficiently detailed to allow any sound quantitative analysis regarding the amount of radon absorbed.

5. The clinical studies indicate that no injurious results may be expected from this type of treatment.

The authors are very greatly indebted to Dr. B. A. Veebrink, of New York, for valuable advice and suggestions regarding the preparation of the radon water, and to Dr. E. U. Condon, Director, and Dr. L. F. Curtiss, Chief of Radioactivity Section, of the United States Bureau of Standards, Washington, D. C., and their associates for the analyses of the many air samples collected in this study.

Discussion

Dr. H. J. Behrend (New York): Radium emanation in the form of inhalations, drinks and baths, has been used for its curative effect for many decades. A vast literature exists as to the physics and the physiologic effects of the products of the disintegration of radium and their clinical applications. People have flocked to spas, like Bad Gastein or Joachimmsthal, which have radioactive waters, and improvements in many ailments have been reported. Apparatus for the artificial preparation of baths containing the first product of the disintegration of radium, radon, have been used for many years. This form of therapy, however, was not very popular in this country, despite these facts, because of untoward and unfortunate complications observed with the use of radium products, mainly in industry.

The attempt of the essayists to review and to elaborate on the physiologic effects of radon baths is therefore most gratifying. Drs. McClellan and Comstock have cited the literature reporting absorption of radon through the skin and an increase of absorption in combination with carbon dioxide baths. They were able to confirm these findings in their experiments. It is a well established fact that many substances, especially gases, are absorbed by the skin. The best known of these gases is carbon dioxide. The essayists report that absorption by the skin of radon with plain water baths is less than with carbonated baths. I agree with the essayists that the hyper-

emia of the skin resulting from the carbon dioxide may be one of the reasons for this fact. They also state that carbon dioxide when absorbed by the skin from the bath water may act as a vehicle to increase the absorption of radon. The theory may be found confirmed in the literature. It is known in gastrointestinal physiology that absorption in the stomach is improved by carbonated drinks. In 1933 Eimer reported that in experiments on white mice percutaneous absorption of salicylic acid and of alcohol in watery solutions was accelerated after carbon dioxide had been added to the solution. Hyperemia of the skin may be one cause of this acceleration. Another may be the fact that the acidity of the bath caused by the carbon dioxide increases the permeability of the skin. Eimer reported that absorption of those substances was best which were present in a weakly acid reaction. It may therefore be definitely assumed that water acts as a vehicle to increase the absorption of radon.

The statement of the essayists that no untoward reactions were observed from this type of treatment, and that none may be expected, will be welcomed by the clinicians and by the public. I am able to confirm that no injurious results were observed during the treatment of 10 patients who received radon baths at the Hospital for Joint Diseases in New York. We have been using the same apparatus as described by the essayists. Drs. McClellan and Comstock have not yet reported their clinical results obtained in their patients. My own experience is rather small and inconclusive. Some patients improved; others did not. All had rheumatoid and osteoarthritis. These results should not speak against a form of therapy which has been well established in European spas and in spas on this continent. They merely bring out the difficulty of objective studies in generalized hydrotherapy. All my patients were ambulatory, and every one realizes the difficulty of controlling the patients' activity outside the hospital and in their homes during a course of treatments of nonspecific nature. These facts again prove the necessity of establishing research centers in hydrotherapy to promote this branch of physical medicine and to confirm and elaborate on forms of therapy which are well known for their curative effects but the rationale of which is not entirely understood, as, for instance, radon baths.

The essayists have contributed a paper of value for the understanding of the much neglected radon therapy and for hydrotherapeutic research.

ARTIFICIAL ULTRAVIOLET IRRADIATION AS A RELATIVE PROTECTION AGAINST PHOTOSENSITIVITY *

Report of Four Cases

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Four cases of physical allergy to sunlight (idiopathic photosensitivity), reference to 2 cases reported in the literature and a method which affords promise of producing relative protection against light ray allergy are presented.

It is generally accepted that the erythema maxima are at 2,967 and 2,500 Å[1]; that after strong ultraviolet irradiation histologic changes result, including capillary dilatation, leukocyte infiltration from the capillaries in the corium to the epidermis with eventual thickening of the stratum corneum, and some pigment deposition in the basal cells of the epidermis. Protection against sunburn is provided chiefly by thickening of the corneum, which limits penetration of the radiation.[2] Similar corneal thickening and protection are said to be produced by the "hot quartz" lamp.[3] It is not known, however, whether these results can be effected by the "cold quartz" lamp. No reference was found in the literature relating to the extent of the thickening of the stratum corneum to the various wavelengths of light.

Members of the white race may arbitrarily be classified, for convenience, into three groups according to their reactions to sunlight:

Group 1: Normal or average reactors. In this group are included brunets or blonds of average skin texture who possess a "normal" resistance to sunlight.

Group 2: Sensitive reactors. This group includes blonds and redheads with light complexion and tender skin who become quickly and easily sunburned and have never been able to develop a natural temporary resistance to sunlight.

Group 3: Hypersensitive reactors. This group includes the persons with idiopathic photosensitivity; certain blonds and redheads, and occasionally a brunet who displays marked local and general reactions (allergic) when exposed to the sun's rays for a very brief period.

The effectiveness of the cold quartz lamp in providing relative protection against sunlight has apparently been untested. Treatment for protection of the photosensitive patient was carried out by me to determine whether such protection could be artificially induced. Since the cold quartz lamp was the only ultraviolet burner available at the hospital at which I was stationed, it had to be the type employed. This was used despite the conviction that a hot quartz lamp would have been more effective.

For a number of years before World War II, it was my belief that a

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1. Coblentz, W. W.: The Physical Aspects of Ultraviolet Therapy, J. A. M. A. **111**:419, 1938.
2. Blum, H. F.; Eicher, M., and Terus, W. S.: Evaluation of the Protective Measures Against Sunburn, Am. J. Physiol. **146**:118, 1946.
3. Rudd, J. L.: Induced Resistance to Prolonged Sun Exposure, Arch. Phys. Therapy **25**:345, 1944.

finite although moderate degree of relative immunity against the effects of solar exposure could be attained by almost all persons of average sensitivity to solar radiation (group 1). To produce this result, a 1 degree erythematous reaction was produced in patients exposed to artificial ultraviolet radiation for one-half minute at a 30 inch distance from the hot quartz or for one minute at a 24 inch distance from the cold quartz lamp. The radiation of either lamp was applied to four portions of the body, with the dose increasing in increments of about one-half minute at subsequent treatments. The relative immunity was attained in approximately eight treatments. The treatment to patients in group 1 permitted the average brunet to endure exposure to midsummer sun for one to one-half hours with only a slight erythema, whereas prior to radiation an exposure for one hour would cause an uncomfortable second to third degree erythema persisting from seven to ten days.

Subsequently it was possible to confirm the view that such resistance was attainable by artificial means by treating persons sensitive to sunlight (group 2) with the hot quartz lamp.[3] The technic was as follows: radiation from the hot quartz mercury vapor arc with a minimal erythema dose of fifteen seconds at a distance of 30 inches was applied to the light-sensitive patients every third to fifth day. The duration of exposure to the artificial irradiation was increased in successive treatments in increments of fifteen to thirty seconds (depending on the skin reaction to the previous applications) until a treatment time as high as four or five minutes was reached for each of four sections of the body. After this treatment it was felt that the patient was ready to attempt exposure to natural sunlight. It was found that the once photosensitive persons could readily withstand increases in exposure time, with definite protection against sunburn.

In the present study, which involved the hypersensitive reactors (group 3), an essentially similar technic was employed, the cold quartz lamp being used. Even these photosensitive patients, when exposed to a series of radiation treatments, developed a relative immunity to sunlight. The use of small method of injecting fractional doses of allergenic agents for prophylaxis of hay doses of ultraviolet radiation in this method is somewhat comparable to the fever.

Watkins,[4] in his discussion of infra-red urticaria in a patient who reacted with a blotchy erythema when exposed to sunlight, stated that "the face and more frequently exposed surfaces of the extremities were less sensitive than the trunk. At the end of the summer some tolerance apparently developed, for the extremities showed reactions only after excessive exposure and the face almost never."

Duke[5] noted that application of light at daily intervals was associated with a considerable degree of local tolerance, so that after repeated applications of light a twenty-five minute exposure produced less effect on the skin than could be produced by a two minute exposure of untreated areas. This case, like that of Watkins, demonstrated that the face, neck, hands and forearms, which are naturally exposed to light at frequent intervals, were much more tolerant of light than covered areas, such as the chest, shoulders and back.

These cases represent examples of light-sensitive patients who were automatically afforded a relative immunity to sunlight by small doses of sunlight over a period of months. In the cases to be presented a similar protection was sought, in a shorter time, by the application of artificial ultraviolet irradiations to a group of men highly sensitive to the sun's rays when exposed to such rays in a semitropical climate.

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4. Watkins, A. L.: Infra-Red Urticaria, Arch. Phys. Therapy 24:291, 1943.
5. Duke, W. W.: Urticaria Caused by Light, J. A. M. A. 80:1835, 1923.

Four cases are presented in which there was some unusual sensitivity to solar radiation. The four patients were treated with artificial ultraviolet rays from a cold quartz generator. The relative immunity afforded these patients by a series of gradually increasing doses of ultraviolet treatments is described in the following reports.

Two of the 4 patients were so markedly hypersensitive to sunlight that, even in the temperate climate of their home states, they were subject to "heat exhaustion" and "heat stroke" in the summer sun. One of the men who suffered from solar hypersensitivity and who reacted favorably to the prophylactic doses of ultraviolet had once before observed a lessening of his sensitivity following a series of gradual preventive exposures to the cold quartz generator. It is interesting to note that it was not the humidity nor the high temperature that affected these patients. They reacted unfavorably only upon exposure to sunlight, or following exposure to ultraviolet irradiation. The ultimate benefit which they derived from prophylactic artificial ultraviolet treatment is probably best explained on the basis of a thickening of the stratum corneum which limited penetration of solar radiation.

Report of Cases

Case 1. — F. S., aged 22, of Norwegian ancestry, recalled that in 1933, at the age of 16, he was unable to remain in the sun for more than a half-hour without acquiring a severe headache lasting two or three days. Most of his time had been spent indoors, at home, in school or at work, in Philadelphia. Heat in the shade had no effect upon him, but heat in the sun produced symptoms.

While swimming, in June, 1933, after a half-hour exposure in the sun, he became dizzy, and unconsciousness followed. He remained in a coma for about three hours. He was confined to his bed for two weeks after this attack. Other than a hot and cold sensation which occurred before he collapsed, he recalled no other prodromal symptoms.

After this episode he took cold quartz ultraviolet treatments, to produce a 1 degree erythema, beginning with thirty seconds with gradually increasing dosage until he was receiving a three minute exposure over four areas of the body. Applications were given at a 24 inch distance three times a week. These treatments were made readily accessible to him as an employee of a laboratory that used this physical agent.

After the series of irradiations he was able to remain in the summer sun from one and one-half to two hours during the noon period with practically no ill effects, the only after-effect being an erythematous eruption. The prophylactic treatment which was taken in April and May had reduced his hypersensitivity to the radiation of the midsummer sun.

In January, 1943 he was exposed to the sun on a Hawaiian island for a half-hours, after which headache, nausea and weakness and a second degree sunburn developed. In April of that year he was given a series of ultraviolet treatments similar to those he had had above, after which he was able to stay in the tropical (or semi-tropical) July sun for one to one and one-half hours without any deleterious after-effects.

Case 2. — A. G., a very fair-skinned, red-haired man, 34 years of age, was referred from the dermatology section with a diagnosis of "dermatitis actinica." He was aware of an excessive sensitivity to the rays of the sun even in Ohio, where he lived and where he could stand solar exposure no longer than fifteen minutes. After a short exposure he experienced headaches, dizziness, "pressure" in his head, weakness, nausea and vomiting. He had fainted on numerous occasions and had had "sunstrokes." After thirty minutes in the sun definite blisters would develop. He had never been able to become tanned. The California and the Pacific island sun bothered him much more than did the actinic rays of the sun in his native Ohio environment.

To secure a 1 degree erythema, radiation from the cold quartz ultraviolet generator at 24 inches was given for ten seconds to four parts of the body every other day. The dose was increased, five seconds at first and then ten seconds, as tolerance developed. In three weeks the dose could be increased to fifty seconds, with an occasional reaction consisting in an uncomfortable erythema. Although at that time he admitted an ability to remain in the sunlight for one-half to one hour without discomfort, he was so eager to return home that he was "shipped out" before further observations could be made.

Case 3. — A. T., a 24 year old man, had a definite allergy to sunlight as well as to

many foods. An urticarial reaction was manifested when he was subjected to sunlight for as little as three to five minutes. The reaction would appear a few hours later and was not localized to the area of the body that was exposed to the rays. If the bare arms received the solar radiation, the urticarial wheals often appeared on the thighs (reflex type of reaction).[6] A delayed rash resulted from less than five or ten minutes in the sun. The patient's hair was dark brown, but his skin appeared to be of an unusually fine texture; his eyes were light colored. After routine skin tests for sensitivity to ultraviolet rays, it was decided that for a first degree erythema radiation for one-half minute at 24 inches, from the cold quartz generator, was the best dose to use in this case, in which delayed reactions and reflex type of reaction were the chief results of irradiation.

Three hours after the initial application to his back (July 1), his ears began to swell. Because of his hypersensitivity the dose was not increased at the second treatment. On July 5, the third treatment, with no further increase in exposure factors, produced hives over the right hip, right buttock and left arm. The rash appeared to form in about five hours following the treatment, and it increased in size until it reached its maximum in about eight hours after the onset of treatment (delayed reaction).[6] The decided swelling, redness and itching prevented him from sleeping.

On July 14, after completing eight treatments from the cold quartz ultraviolet burner, the last one for two minutes at 24 inches, the patient was outdoors in sunlight for two hours and had no reaction even though he was wearing a short-sleeved shirt and had no head covering. The treatments resulted in an occasional rash, but this was mild and would last only a short time compared to the reaction before treatment. A definite relative temporary immunity to sunlight was achieved by this patient sensitive to food and light.

Although this case is not strictly one of physical allergy, the patient presented an unusual local susceptibility to sunlight due to a dermatologic condition.

CASE 4. — J. C., a sailor, with nevus flammeus of the face, was referred by the dermatologist to receive treatment to diminish the tendency of the lesion to flare up after a few minutes' exposure to sunlight. The symptoms and signs consisted in itching, bleeding and redness of the face. The condition was present at birth. Since the patient had left Illinois and gone out to the Pacific area, the bleeding and itching of the lesion were noticeably increased. The symptoms were seldom troublesome in his native environment. Two roentgen treatments had been given without relief. He was given ultraviolet irradiation from a cold quartz generator for fifteen seconds at a distance of 18 inches, to produce a first degree erythema. One month later he was receiving a two minute treatment at 18 inches. The bleeding and rawness had diminished. The patient still complained of itching, but there was no burning when he was out in the sunlight for forty-five minutes. He was given ultraviolet therapy twice a week after he had returned to a Naval Air Station for duty. His condition was definitely improved.

Summary

A method was developed which offers promise in producing relative protection against hypersensitivity to solar radiation. The method consists of graduated doses of artificial irradiation from a controlled ultraviolet source (cold quartz lamp). Four illustrative cases are reported in which applications of the method appeared to produce a temporary reduction in hypersensitivity to solar radiation.

6. Duke, W. W.: Heat Regulation and Disorders of Heat Regulating Mechanism — A Type of Physical Allergy, in Cyclopedia of Medicine, Surgery and Specialties, Philadelphia, F. A. Davis Company, 1946, vol. 7, p. 130.

ELECTRIC STIMULATION OF DENERVATED MUSCLE *

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As early as 1841 John Reid[1] suggested the use of electric stimulation as a treatment for paralyzed muscle. Over a century of clinical use, however. has failed either to settle the controversy as to its value or to bring any agreement as to the most effective methods of applying electrotherapy for this purpose. It is only in recent years, since the intensive experimental investigation of this problem, that the type of detailed facts are being collected which will in time permit a clear definition of the proper position of electric stimulation in the treatment of denervated muscle.

Since 1939 there has been a steady stream of favorable reports by Fischer,[2] Gutmann,[3] Solandt,[4] Grodins,[5] Kosman,[6] Hines[7] and their respective coworkers indicating that electric stimulation can certainly retard some of the progressive changes occurring in skeletal muscle after denervation. These reports cover a large number of well controlled experiments in which the number of animals used was adequate. These workers have demonstrated beyond doubt that electric stimulation under certain conditions can retard the progressive loss of weight and volume characteristic of denervation atrophy.

Gutmann and Guttmann[8] have demonstrated distinct morphologic differences between treated and untreated muscle. The macroscopic appearance of treated muscle hardly differs from the normal. Its red color contrasts strikingly with the pallor of untreated muscle. Histologic examination shows fibers of greater average diameter, with more apparent cross striation and — what may be most important — distinctly less interstitial connective tissue in the treated muscle. The histologic appearance is not the same throughout. Evidently there is a greater effect upon fibers which lie close to the treating electrodes. The outer parts are almost normal, whereas in deeper parts atrophy is not as effectively prevented. But no part of the treated muscle shows as advanced atrophy or fibrosis as the untreated muscle.

Fischer and Ramsay[2b] have demonstrated that electric stimulation effectively retards the following characteristic chemical changes in muscle undergoing denervation atrophy: decreases in total protein, in noncollagenous protein, in myosin and in nonprotein nitrogen and increases in collagen protein and hydrophilic power. Hines[7c] has demonstrated that denervation loss in muscle glycogen and creatine can be favorably influenced. Gutmann and Guttmann[3] have observed that treated muscle contracts more briskly, and Fischer[2a] has shown that treated muscle is less fatigable. Fischer,[2a] and Gut-

* Read before the New York Society of Physical Medicine.

* Published with permission of the Chief Medical Director, Department of Medicine and Surgery, Veterans Administration, who assumes no responsibility for the opinions expressed or conclusions drawn by the author.

1. Reid, J.: London & Edinburgh Monthly J. M. Sc. **1**:320, 1841.
2. (*a*) Fischer, E.: Am. J. Physiol. **127**:605, 1939. (*b*) Fischer, E., and Ramsey, V. W.: ibid. **145**:583, 1946.
3. Gutmann, E., and Guttmann, L.: Lancet **1**:169, 1942.
4. Solandt, D. Y.; DeLury, D. B., and Hunter, J.: Arch. Neurol. & Psychiat. **49**:802, 1943.
5. Grodins, F. S., and Others: Am. J. Physiol. **142**:222, 1944.
6. Kosman, A. J.; Osborne, S. L., and Ivy, A. C.: Am. J. Physiol. **145**:447, 1946.
7. (*a*) Hines, H. M.: J. A. M. A. **120**:515, 1942. (*b*) Hines, H. M.; Thomson, J. D., and Lazere, B.: Arch. Phys. Therapy **24**:69, 1943. (*c*) Hines, H. M., and Wehrmacher, W. H.: J. Iowa M. Soc. **34**:142, 1944. (*d*) Wehrmacher, W. H.; Thomson, J. D., and Hines, H. M.: Arch. Phyys. Med. **26**:261, 1945.
8. (*a*) Gutmann, E., and Guttmann, L.: J. Neurol., Neurosurg. & Psychiat. **7**:7, 1944. (b) Footnote 3.

mann and Guttmann[8a] have found that the later changes in excitability, as measured by increasing chronaxie, are retarded by electric stimulation.

Neither Hines[7c] nor Gutmann and Guttmann,[8a] who specifically studied the problem, have noted any influence upon the speed of functional reinnervation in short term experiments, indicating that electric stimulation neither hastens nor retards axon growth or its establishment of functional reconnection directly. Doupe, in a series of clinical cases in which nerve suture had been performed, found that the time of reinnervation was entirely dependent upon the level of the lesion. Paul Weiss, summarizing twenty-three years of outstanding experimental work on nerve regeneration, stated that nerve fibers are not guided by galvanotropic influences.

Muscle undergoing atrophy from whatever cause loses strength. In denervation atrophy, however, as distinguished from other types of atrophy, the loss of strength is greater than can be accounted for by loss of muscle mass. There is an actual decrease in strength per unit of remaining muscle. It has been shown by Fischer and Suskind[9] that this deterioration in strength is not influenced by electric stimulation. Although the larger treated muscle can develop more tension, this is entirely due to greater mass and is not due to any improvement in muscle power. Studies of birefringence with polarized light is one of the optical methods used to study the structure of matter beyond the level of the ordinary light microscope. Birefringence is a basic optical property, and any change in it reflects some change in fundamental structure. During the very early stages of denervation atrophy, when the strength per gram of muscle remains unchanged, this property is unaffected. As the strength per gram of muscle deteriorates with further atrophy, there is a corresponding progressive loss in birefringence. Electric stimulation fails to influence the changes in this optical property induced by denervation. These two lines of evidence indicate that the fundamental contractile structure deteriorates in spite of electric treatment. But I should hesitate to accept the idea that electric stimulation has no influence on the contractile mechanism until the significance of certain indirect evidence is clarified. In this connection, a special word about myosin. Those who speculate about how the metabolic changes in muscle result in shortening consider myosin the subtrate of the contractile mechanism. It is felt that contraction is caused by a change in molecular configuration of myosin of a labile, reversible nature. Fischer and Ramsey[2b] have shown that electric stimulation does significantly retard the loss of myosin. If myosin should prove to be as important to the contractile mechanism as present expert opinion has it, it would seem very likely that a therapeutic agent which prevents its loss is acting in the direction of preserving the contractile mechanism, even though this might not be reflected in tension or birefringence measurements.

When electric stimulation is delayed until after reinnervation, the evidence from experiments by Hines[7b] and Kosman[6] is that there is no effect upon the ensuing recovery of weight and tension. Apparently when reinnervation takes place, recovery proceeds at a maximum, provided no obstacle such as immobilization is present.

After reinnervation, treated muscle attains its normal measurements and strength more quickly. A variable time after reinnervation, however, these differences are equalized — that is, the treated and untreated muscle become approximately the same in weight and strength. It bears emphasis that the experiments of Kosman and of Hines upon which this conclusion has been

9. Suskind, M. L.; Hajek, N. M., and Hines, H. M.: Arch. Phys. Med. 27:133, 1946.

made involve short periods of denervation, and the statement may not hold true in prolonged denervation.

One of the most gratifying results of these favorable reports is a clarification of just what sort of treatment regimen will retard atrophy with uniform regularity. First of all, it is clear that all those who have obtained favorable results have attempted to produce maximal contractions. Hines,[7b] investigating this experimentally, found a direct relation between strength of current and effectiveness; strong currents producing the most vigorous contrations are most advantageous. Gutmann and Guttmann[8a] also found that weak currents producing minimal contractions had insignificant effects. Hines[7c] made an important contribution to the further analysis of this factor in his experiments on the effect of supramaximal stimuli on tenotomized, denervated muscle. It is apparent that comparatively little tension is developed upon contraction of a muscle with a cut tendon. Under these conditions, intense electric stimulation was found to be ineffective in retarding atrophy. This has been confirmed by Fischer and Ramsey,[2b] who found electric stimulation more effective when muscle shortening was resisted, than when the muscle was allowed to shorten freely. From this work it can be seen that intense stimulation is of importance only to the extent that it is required to produce maximal tension.

Since the production of maximum tension appears to be of such importance, physiology of the development of tension during muscle contraction should be kept in mind. The strength of a twitch contraction can be graded by increasing the intensity of stimulation. When the maximal twitch is obtained, all the fibers capable of being excited at the moment are being activated. The strength of contraction can be further increased by summation of repetitive stimuli. If the stimuli are applied at the proper frequency, instead of individual twitches, there is obtained a smooth, fused, maintained contraction, in which the repetitive nature of the stimulus and response is not apparent. Such a tetanus produces about four times the tension of a maximal twitch. The particular frequency required for production of tetanus depends upon the duration of the twitch contraction. The shorter the duration of twitch, the higher the frequency of stimulation required for fusion. Since denervated muscle responds with a slow contraction, the optimum frequency for production of tetanus will be low as compared with normal muscle. It has also been known for a long time that the initial muscle length bears a relation to the tension developed. The maximum isometric tension occurs with the muscle fibers at resting length, the amount of tension achieved falling off rapidly as the muscle fiber is either stretched to greater lengths or allowed to shorten to lengths less than that at rest. Since the importance of tension has not been recognized until very recently, it is not surprising that these facts have been largely ignored in clinical work.

There is a direct relation between frequency of treatment and effectiveness. Solandt,[4] comparing the relative effectiveness of one, three and six treatments periods daily, found a linear relationship between frequency of treatment and retardation of atrophy. Gutmann and Guttmann[8a] found treating twice weekly ineffective as compared to daily treatment. Wehrmacher[7d] confirmed this in experiments in which they treated every other day, daily, and twice a day.

Experimental evidence would seem to indicate that the length of individual treatments is of minor, if any, importance. In 1941 Eccles[10] studied the effect of varying lengths of stimulation in preventing total disuse atrophy.

10. Eccles, J. C.: M. J. Australia 2:160, 1941.

It was a complete surprise to find that all periods of stimulation from ten seconds to two hours daily were equally effective. Applying this conclusion to denervated muscle, Solandt[4] found no difference in results when one, two, three and five minute daily treatments were given. Wehrmacher,[7d] varying the length of treatment from three to one hundred and eighty seconds found that effectiveness was practically independent of length of treatment in this range.

Fischer[2a] obtained his best results when stimulation was started immediately after denervation. Gutmann and Guttmann,[8a] comparing treatment started seven and sixty days after denervation, found early treatment more effective in retarding both atrophy and the formation of fibrous tissue.

It is impossible to make an adequate appraisal of the role of electric stimulation in the treatment of denervated muscle without detailed consideration of some of the known facts about the mechanics of nerve regeneration, with particular attention to the progressive histologic changes in muscle with increasing lengths of time, which make full reinnervation progressively more unlikely.[11] Although most of this work has been done on experimental animals, the muscle biopsy studies of Bowden and Gutmann,[12] on human peripheral nerve injuries with varying periods of denervation are confirmatory. The axon of the central end of a cut nerve has the capacity of growth, and when the proper unobstructed path exists it can regain its previous end plate. Full regeneration of nerves, however, is not complete when the nerve has regained its muscle connection. It must also recover its normal diameter, since its physiologic properties are directly related to diameter. After degeneration of the peripheral stump, the Schwann tubes remain and constitute the channels along which the regenerating nerve fibers grow. And the diameter of the Schwann tubes, if unchanged, preserves the characteristic pattern of fiber size of the particular nerve involved. When the period of denervation is short, nothing happens either to the Schwann tubes or in the muscle to interfere with full regeneration. When, however, denervation is maintained for prolonged periods, regardless of the reason, changes occur which progressively lessen the likelihood of full reinnervation. First of all, the Schwann tubes shrink. This may make it impossible for full restoration of fiber diameter to take place. Increasing fibrosis closes off the Schwann tubes, forcing the nerve to make new end plates, a delayed and less efficient type of reinnervation. Fibrosis also completely isolates more and more muscle fibers, with the result that more and more fibers fail to be reinnervated, even though the axon has reached the muscle. Even those nerve fibers that do make end plate connections are abnormal in that the terminal branches are fewer and thinner. That such considerations are important in man is indicated by electromyographic studies which record isolated fibrillation potentials characteristic of denervated muscle long after return of voluntary function[13] and by cases of long delayed nerve suture with failure to recover function, in which biopsy shows abundant nerve fibers in the severely atrophied, fibrotic muscle which just have not made contact.[12] If denervation lasts long enough, the muscle fibers become fragmented and ultimately disappear entirely.

It is apparent that these events may outweigh all other consideration in determining whether or not any effect can be expected from electric treatment in a particular case. These facts also suggest the thought that in seeking an adequate treatment for denervated muscle this concentration of all attention on those factors that delay weight loss may be making one blind

11. Young, J. Z.: Tr. Am. Neurol. A. 69:41, 1943. Sanders, F. K., and Young, J. Z.: J. Physiol. 103:119, 1944.
12. Bowden, R. E. M., and Gutmann, E.: Brain 67:273, 1944.
13. Weddell, G.; Feinstein, B., and Pattle, R. E.: Brain 67:178, 1944.

to other possibilities. It may be just as important to give consideration to modes of therapy that may minimize the fibrosis which progressively interferes with reinnervation, regardless of their effect on weight loss, etc. It seems perfectly feasible to expect benefit from a therapy that would never elicit a contraction, provided it lessened fibrosis, and provided this actually did improve the chances of functional reinnervation. Milder applications of electrotherapy or other physical agents have not received the proper controlled clinical study or experimental investigation from this point of view. I am not asserting that such other treatment is beneficial. However, I am suggesting an attitude toward the entire problem which, taking account of some generally neglected facts, may be productive.

Whether or not intensive electric stimulation started early can preserve a normal histologic structure of muscle during prolonged periods of denervation is not known with certainty. The work of Gutmann and Guttmann on a limited number of animals showing that early treatment does minimize the amount of fibrosis in denervation maintained for about three months is suggestive. But whether or not this can be achieved in prolonged denervation, which is so characteristic of human material, can be proved only by further experimental work. It is also not known whether electric treatment puts off the day when denervated muscle fibers fragment and become completely replaced by fibrous tissue. These gaps in our knowledge prevent a complete evaluation of the role of electric stimulation in the treatment of denervated muscle.

Summary

1. The following favorable effects can be expected from electric stimulation; a heavier, larger, and less fatiguable muscle which contracts more briskly; a muscle more nearly normal from the point of glycogen, creatine, phosphocreatine, myocin, protein, collagen, and water content; and a muscle more normal in macroscopic and histologic appearance. In short, a muscle which requires much less recovery to return it to its normal state.

2. To consistently duplicate such results treatment may be short, but it should be started early and administered frequently. It is necessary to develop maximum tension. To attain this end a tetanus is required, and it is necessary to restrain muscle shortening during contraction.

3. The significance of changes in the Schwann tubes and in the muscle during prolonged periods of denervation has been considered.

4. The need for filling certain gaps in our knowledge before a full evaluation of electric stimulation in the treatment of paralyzed muscle can be made has been pointed out.

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.˙. EDITORIALS .˙.

MICROWAVE DIATHERMY — A DOUBLE PROGRESS

This issue of the ARCHIVES brings the fourth[1] and final of the series[2,3,4] of papers presented on Microwave Diathermy before the 26th Annual Session American Congress of Physical Medicine. These papers and two others previously published[5,6] are the result of over a year's measured laboratory and experimental studies after the original publication[7] on the subject. In the studies carried out by several groups of independent investigators, not only the various and at times seemingly controversial aspects of the physical and physiologic effects of the microwave energy were fully investigated, but also its possible injurious effects. There appears to be unquestionable evidence that microwave diathermy offers a newer form of efficient physical means for temperature increases in selected areas of the body. Although in many respects microwave diathermy represents a form of high frequency appplication quite different in some of its physical aspects from the two older methods, no claims for any specific or spectacular clinical results are being made as yet by its investigators. The procedure itself has been clarified to that extent that any physician can now safely embark, in accordance with the precautions outlined, to use this convenient form of deep tissue heating in his own practice. Clinical experience on an extended scale should determine, after a number of years, in what clinical conditions microwave diathermy is more effective or may be more preferable.

Many will remember the circumstances under which the immediate predecessor of microwave diathermy, shortwave diathermy was launched from abroad less than twenty years ago upon the medical profession; they cannot fail to be impressed by the sharp contrast between that "promotion" and the course followed in presenting the new American contribution. In the case of shortwave diathermy a veritable avalanche of propaganda asserted right from the beginning that shortwave and especially ultra shortwave diathermy was something radically different from any other form of physical treatment; that it had specific heating effects by certain wavelengths, specific high frequency and bacteriocidal effects; also specific biological effects on capillaries and on tumors. It was also asserted that it had clinical effects of far-reaching importance in combating acute inflammatory and purulent conditions. The literature of almost seven hundred articles published during

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1. Gersten, J. W.; Wakim, K. G.; Herrick, J. F., and Krusen, F. H.: The Effect of Microwave Diathermy on the Peripheral Circulation and on the Tissue Temperature in Man, Arch. Phys. Med. **30**:7 (Jan.) 1949.
2. Worden, R. E.; Herrick, J. F.; Wakim, K. G., and Krusen, F. H.: The Heating Effects of Microwaves With and Without Ischemia, Arch. Phys. Med. **29**:751 (Dec.) 1948.
3. Siems, L. L.; Kosman, A. J., and Osborne, S. L.: A Comparative Study of Short Wave and Microwave Diathermy on Blood Flow, Arch. Phys Med. **29**:759 (Dec.) 1948.
4. Richardson, A. W.; Duane, T. D., and Hines, H. M.: Experimental Lenticular Opacities Produced by Microwave Irradiations, Arch. Phys. Med. **29**:765 (Dec.) 1948.
5. Kemp, C. R.; Paul, W. D., and Hines, H. M.: Studies Concerning the Effect of Deep Tissue Heat on Blood Flow, Arch. Phys. Med. **29**:12 (Jan.) 1948.
6. Osborne, S. L., and Frederick, J. N.: Microwave Radiations; Heating of Human and Animal Tissues by Means of High Frequency Current with Wavelength of Twelve Centimeters (the Microtherm), J. A. M. A. **137**:1036 (July) 1948.
7. Krusen, F. H.; Herrick, J. F.; Leden, Ursula, and Wakim, K. G.: Microkymatotherapy: Preliminary Report of Experimental Studies on the Heating Effect of Microwaves ("Radar") in Living Tissue, Proc. Staff Meet., Mayo Clinic, **22**:209 (May 28) 1947.

a span of a few short years, contained statements like this: "It is no exaggeration to call shortwave diathermy the greatest discovery of physical medicine since the work of Roentgen" and "Every normal tissue cell has a radio frequency of its own and by application of shortwaves of proper frequency, any abnormal tissue may be restored to function." Gullible physicians were told to discard their spark gap diathermy apparatus immediately and buy the expensive ultra-shortwave apparatus — eagerly exploited all over the world by some large German concerns and their subsidiaries. Time, clinical experience and extended investigations, have amply disproven most of these earlier assertions. Many of the older types of longwave apparatus are still giving excellent service and enable some useful and unique forms of treatment technic which are not possible with shortwave diathermy.

It is a mark of double progress that in the advent of microwave diathermy some of the flamboyances of shortwave diathermy propaganda have been scrupulously avoided. For this the credit is due perhaps, in the first line, to the consistent educational efforts of the Council of Physical Medicine of the American Medical Association and second, to our present generation of well trained and objective research workers and clinicians and finally, of course, to the whole-hearted cooperation of an enlightened manufacturing group.

THE PROBLEM OF SAFETY IN THE USE OF RADON

Radium emanation has been used therapeutically for some forty years, following the discovery of radium by Mme. Curie in 1898. There is confusion in some minds between radium or radon. Radium is a transformation product of uranium, its atomic weight being 226; radon or radium emanation is a heavy gas and a product of the disintegration of radium; its atomic weight is 222. Much of the effectiveness of Spa treatment has been ascribed to radioactivity, although up to this time it has been impossible to give even an estimate of dosage in relation to radium content. The literature contains a curious mixture of confusion and tolerance regarding the subject of radium bath and radium drinks. They are advocated in a great number of conditions, rheumatic, dermatologic, gynecologic, nose and throat, etc., and there is no lack of enthusiastic testimonials as to their efficacy. Yet practically all these ardent advocates of radon therapy, lose sight of the fact that there is an unavoidable danger with the systematic administration of a radioactive substance. In the paper presented in this issue by McClellan and Comstock,[1] the facts regarding the absorption and elimination of radon have been well studied; the authors correctly state that the data are not sufficiently detailed to allow any sound quantitative analysis regarding the amount of radon absorbed. If there is to be a large scale therapeutic employment of any radioactive substance, the important aspects of absorption and elimination must receive much further study.

In a fundamental article on radium poisoning based on many years study, Martland[2] states numerous facts which by implication argue against the giving of radioactive baths. Everything he says against the internal administration of radium itself can be used to argue against the use of radon and related substances, for he notes that during the three or four hours that radon is in the body, from one to two per cent of it decays into active

1. McClellan, Walter S., and Comstock, Carl R.: The Cutaneous Absorption of Radon from Naturally Carbonated Mineral Water and Plain Water Baths, Arch. Phys. Med. 30:26 (Jan.) 1949.
2. Martland, Harrison S., in Practitioners Library of Medicine & Surgery, Supplement-Index Volume, pp. 208-219, D. Appleton-Century Co., 1938.

deposits. These are solid substances, some long-lived and small amounts of these may be stored as fixed deposits which emit their characteristic radiations. Martland points out that since radon is being formed continually from radium, and since it is well known now that radon can be absorbed into the body both through the lungs and through the skin and that it diffuses freely throughout the body, it is sure to leave little radioactive residue wherever it goes. Grace[3] asserts that the damage done by radium is irreversible. Hess and McNiff[4] state that the tolerated amount of radium is provisionally set at 0.1 micrograms; however, these estimates of tolerance are a subject of a dispute at present and it is very likely that the quantity considered safe will be reduced in the future. Cipollaro[5] says that the use of radium waters should be discouraged for treatment of cutaneous diseases, for the efficacy of radium waters has never been proved, and radioactive substances absorbed through the skin or taken internally even in minute doses have a cumulative effect which can cause degenerative changes and even death.

It is on account of these unquestionable possibilities of deleterious effects that the Council on Physical Medicine of the American Medical Association looks very definitely askance at any method employing potent forms of any radioactive material for prolonged periods. It will take controlled observations extending over long intervals, by such outstanding and conservative clinicians as McClellan and Comstock, to change the present, attitude of the Council, notwithstanding the fact that with long years of application of radioactive baths abroad, no definite cases of possible damage have ever been reported.

3. Grace, E. J.: Radium Poisoning, J. A. M. A. **132**:600, 1946.
4. Hess, Victor, F., and McNiff, William T.: Quantitative Determination of Radium Content of Human Body and of the Radon Content of Breath Samples for the Prevention and Control of Radium Poisoning in Persons Employed in the Radium Industry, Am. J. Roentgenol. **57**:91 (Jan.) 1947.
5. Cipollaro, Anthony: The Place of Health Resort Therapy in Dermatologic Disorders, J. A. M. A. **132**:259, 1947.

IMPORTANT DATES FOR YOUR 1949 CALENDAR

The year 1949 holds forth quite a number of events of national and international interest to physiatrists and their technical aids:

February 28th to March 4th: Galveston, Texas. The fourth of the yearly courses on the progress of physical medicine and medical rehabilitation is offered. These early Spring gatherings at the hospital medical center on the Gulf have become a favorable rallying point for physician and technicians from all points of the country. This year's program, as published in this issue, contains lectures of interest to everyone by a galaxy of speakers.

May 30th to June 3rd: New York City. The Seventh International Congress on Rheumatic Diseases will be held at New York's Waldorf Astoria Hotel. Distinguished clinicians and research workers from all parts of the world will report on all aspects of the fight against rheumatism. Physical medicine should play a relatively large role in this work and there will be special sessions and clinical demonstrations devoted to this aspect. A preliminary announcement appeared in the December issue of the ARCHIVES.

June 4th to July 10th: Atlantic City. The annual meeting of the American Medical Association will, for the first time, have two sessions on physical medicine and there is justified hope that the long sought for establishment of a section on physical medicine will be consummated at this meet-

ing. The American Board on Physical Medicine will hold its third qualifying examination in conjunction with this session on June 4th and 5th.

September 6th to 10th: Cincinnati, Ohio. The 27th Annual Scientific and Clinical Session of the American Congress will be held at the thriving and cultured metropolis on the crossroads to the south. This is the second time the Congress of Physical Medicine meets at Cincinnati; the splendid hotel accommodations and the great interest of the local medical profession are well remembered from the last time. Let our own annual meeting be the crowning event among the medical meetings to be attended. It is a must for the entire membership. Detailed announcements of this meeting will appear beginning with this issue of the ARCHIVES. All interested physicians and their technical assistants are welcome.

MEDICAL NEWS

Dr. Knudson New Chief

The Veterans Administration announces the appointment of Dr. A. B. C. Knudson to chief of the reorganized physical medicine rehabilitation division, now under the direction of Dr. Roy Wolford, assistant medical director for professional services. Dr. Knudson replaces Dr. A. Ray Dawson, who recently resigned.

New York Society of Physical Medicine

At the regular monthly meeting for December, the New York Society of Physical Medicine presented the following program: Rehabilitation of the chronically ill with particular emphasis on home care, Martin Cherkasky, M.D., Home Care Executive, Montefiore Hospital (by invitation); Rehabilitation of the amputee, Henry H. Kessler, M.D., Orthopedic Consultant for the Office of Rehabilitation, State of New Jersey (by invitation), and Demonstration of some types of modern prostheses including the vacuum cup, Mr. Alfred Weger, and Mr. George A. Hinkle (by invitation). Discussion was opened by David Unterman, M.D., Director of Home Care, Bellevue Hospital, New York (by invitation), and Mandell Shimberg, M.D., Chief of Physical Medicine Rehabilitation, New York Regional Office, New York (by invitation).

Dr. Karl Harpuder, Chairman of the nominating committee of the New York Society of Physical Medicine, has submitted the following report of the committee for officers for 1949: President, Irwin D. Stein, M.D.; Vice-President, Sidney Licht, M.D.; Treasurer, Richard Kovács, M.D., and Secretary, Madge C. L. McGuinness, M.D. For the Executive committee those nominated are: William Bierman, M.D.; A. W. Schenker, M.D.; H. J. Behrend, M.D., and Jerome Weiss, M.D.

Physical Medicine in the Southern Medical Association

At the 42nd annual meeting of the Southern Medical Association, the section on physical medicine proved to be of much interest, because of the program presented and the participation in the scientific exhibit section. Dr. Temple Fay was the guest speaker. There were nine scientific exhibits definitely in the field of physical medicine. For 1949, Dr. George Wilson was elected as the chairman, and Dr. Jerome Lee, the vice-chairman.

Dr. Hellebrandt on Trip Abroad

Dr. F. A. Hellebrandt, Director of the Baruch Center of Physical Medicine at the Medical College of Virginia, has just returned from an extended tour of the Spas and Health Resorts of Czechoslovakia. She was accompanied by Miss Sara Jane Houtz, research assistant in the Division of Clinical Research and Instructor in the Physical Therapy School. Dr. Hellebrandt and Miss Houtz visited the Balneological Institute of Charles University, the new State Rehabilitation Center at Kladruby and all of the major spas of Bohemia, Moravia and Slovakia. All visitations were made under the auspices of the State as guests of the Czechoslovak government. Nothing was left undone which might have added to the benefits derived from the opportunity of examining the exceptionally fine facilities of the spas and discussing the organization and management of their medical program. All spas and health resorts have been recently nationalized and form

one of the most important adjuncts to the operation of the current State Insurance program.

It was a pleasure to observe the excellent rehabilitation service initiated at Kladruby by the the Unitarian Physical and Occupational Therapy Team for Czechoslovakia.

Docent Juraj Hensel, 1946-47 Baruch Fellow at New York University, is making extensive plans to integrate a comprehensive state wide modern rehabilitation service with the already highly developed spa program of Slovakia. There was much American physical therapy equipment in evidence, obtained largely through the generosity of UNRA.

American physiatrists and their technical assistants can do much to help their colleagues in an area seriously disrupted by the war by establishing personal contact with the Institute of Balneology and Physical Therapy, Charles University, Praha II, Albertov 7, Czechoslovakia, and sending their reprints and teaching aids to the library of this centrally located department. Money exchange difficulties make it virtually impossible for those interested to keep in touch with current developments in physical medicine, rehabilitation and technical education. The importance of positive action now can hardly be overemphasized.

Change in Location

The Baruch Center of Physical Medicine of the Medical College of Virginia has transferred its major activities to the old Memorial Hospital which housed the clinical divisions of the College prior to 1942. These wings will house all clinical services except hydrotherapy, the administrative offices of the Center, the Training School, the clinical research laboratories and the regional office of the State Division of Vocational Rehabilitation. The old Physical Medicine Department in the Medical College of Virginia will be utilized for an expanded program in hydrotherapy.

Training in Physical Medicine

In the fiscal year 1948, substantial progress was made in the training of medical officers and allied technical personnel in physical medicine. Ten Regular Army medical officers completed courses of four and one-half to six months in leading civil medical centers.

The department of physical medicine of the Medical Field Service School, Brooke Army Medical Center, Fort Sam Houston, Texas, conducts training for physical reconditioning personnel and for physical therapy personnel.

Present plans call for the training of medical officers and allied technical personnel, including physical therapists, occupational therapists, and physical reconditioners, at leading civil institutions in the fiscal year 1949.

Annual Congress of Physiotherapists

The Chartered Society of Physiotherapy held its annual congress from Sept. 22 to 26, 1948, in St. Pancras Town Hall, London. For the first time in the Society's history the congress was an international one, invitations having been sent to organizations of physical therapists all over the world; a special session was held for a discussion on international collaboration in physical therapy.

At the opening session, presided over by Dr. W. S. C. Copeman, chairman of council, an address on the National Health Service was given by Sir William Scott Douglas, Secretary of the Ministry of Health.

Dr. E. H. Capel addressed the congress on physical therapy in industry. The Founder's Lecture was delivered by Professor J. L. Witts, with Lord Horder in the chair. Other lectures given in the course of the congress included one on rehabilitation of the injured, by Mr. H. Osmond-Clarke; on the management of the arthritic patient by the physical therapist, by Dr. H. A. Burt; on the role of physical therapy in obstetrics and gynecology, by Professor Green-Armytage; and on the quadriceps in relation to recovery from injuries of the knee joint, by Mr. I. S. Smillie.

Annual Conference of the National Rehabilitation Association

"Community Organization for Vocational Rehabilitation" was the theme of the recent annual conference of the association held in Madison, Wisconsin. Panel discussions were presented on many topics, among them being "Community Organization in Development and Use of Medical Rehabilitation Facilities." As a part of this discussion "The Institute of Rehabilitation and Physical Medicine" was presented by Eugene J. Taylor, Instructor, New York University School of Medicine and member of the Editorial Staff, New York *Times*. Dr. H. H. Kessler, President, National Council on Rehabilitation, gave an outstanding presentation in which he discussed the five different types of rehabilitation centers now in operation.

Cerebral Palsy Fellowships

The National Society for Crippled Children and Adults, 11 S. La Salle St., Chicago 3, will administer a limited number of inservice fellowships for persons specializing in employment problems of victims of cerebral palsy. The fellowships have been made possible by provisions for an annual grant of $5,000 from the Alpha Gamma Delta, international women's college fraternity. Grants will cover expenses including tuition. By surveying public and private counseling and placement agencies, the national society will develop agreements for the training of workers among those agencies about to conduct intensive programs for the physically handicapped.

Drs. Ivy and Youmans Cited for Wartime Service

Dr. Andrew C. Ivy, Vice-President of the University of Illinois, received the President's certificate of merit, and Dr. John B. Youmans, dean of the college of medicine, the Army and Navy certificate of merit, November 6. The certificates are given in recognition for the wartime services of distinguished scientists and engineers of the office of Scientific Research and Development.

Dr. Miller Elected President of Northwestern University

Dr. J. Roscoe Miller, dean of Northwestern University Medical School, has been elected president of Northwestern University and will assume office July 1, 1949. He succeeds Franklyn B. Snyder, who will retire Sept. 1, 1949. Dr. Miller will be the twelfth president of the university.

Dr. Parran to Head New School of Public Health

A new graduate school of public health is being set up at the University of Pittsburgh through a $13,600,000 grant from the A. W. Mellon Educational and Charitable Trust. The first dean of the new school will be Dr. Thomas Parran, former Surgeon General of the United States.

Arthritis Aid Units

The Canadian Press reports that Lord Horder, physician to the King and a leader of the war on arthritic diseases, has planned a squad of two hundred mobile physical therapy units to carry the latest treatment to every small town in England. There will be two fully trained physical therapists to each truck. Trained operators of the electrical equipment have been traveling in Britain for more than a year in twelve trucks.

Loyola University Stritch School of Medicine

This is the new name of this school honoring Cardinal Stritch whose interest in the medical school has merited this recognition. The school has received a gift of 7½ acres on which to build a new laboratory building in the West Side Medical Center and an income of an endowment of at least $50,000 a year for operation of the college. Dr. Frank Lewis was the donor.

Brigadier General Carroll Appointed Dean

Dr. Percy J. Carroll, St. Louis, retired brigadier general, has been appointed dean of Creighton University School of Medicine, Omaha, and chief of staff at Creighton Memorial-St. Joseph's Hospital. He will hold the rank of professor of preventive medicine. He was appointed dean and professor of public health at the St. Louis University School of Medicine in 1946. During World War II he was commandant of the Army Medical Center of Manila and later Chief Surgeon of the Southwest Pacific Theatre of Operations and the Far East. He received the Distinguished Service Medal for his work in evacuating the wounded from Manila. In 1944 he returned to the United States and assumed command of Vaughn General Hospital, Hines, Ill. He retired from the army in 1946.

Emotional Problems of Disabled

A grant of $73,500 from the Commonwealth Fund will be used at New York University-Bellevue Medical Center for a three year research project on the emotional problems of the physically disabled while undergoing rehabilitation training. Dr. Morris Grayson will direct the research. The project will evaluate the motivating factors in physical rehabilitation and the emotional factors that interfere with it and study what psychiatry can contribute in preparing persons for rehabilitation.

Hearing Aids Accepted

The Council on Physical Medicine has voted to include in its list of accepted devices the Maico Audiometer, Model D-9 and Mears Aurophone Hearing Aid, Model 200, with crystal and magnetic receivers.

Research at Temple

Temple University School of Medicine and Hospital has received a grant from the bureau of Medicine and Surgery, U. S. Navy, of $6,180 to Robert H. Peckham, Ph.D., for a research project "The Experimental Determination of Neutrality in Sunglasses."

Motion Pictures Available

A selected list of motion pictures on rehabilitation and Physical Medicine has been prepared by the Department of Rehabilitation and Physical Medicine, New York University College of Medicine.

Pamphlets Available

The U. S. Department of Labor, Women's Bureau, in its series "The Outlook for Woman," has prepared bulletins on chemistry, the biological sciences, mathematics and statistics and physics and astronomy.

Hermann Hospital Approved for Course in Physical Therapy

At the meeting of the Council on Medical Education and Hospitals of the American Medical Association, held in Chicago, October 16-17, 1948, the school for physical therapy technicians conducted by the Hermann Hospital, Houston, Texas, was officially approved.

American Occupational Therapy Association

The American Occupational Therapy Association through its 1949 Convention Committee invites the members of the American Congress of Physical Medicine to attend their 1949 Annual Convention to be held at the Book-Cadillac Hotel in Detroit, Michigan. The dates are as follows:

Convention: Tuesday, Wednesday, and Thursday, August 23, 24, and 25.

Institute: Friday and Saturday morning, August 26, and 27.

Apparatus Accepted

G-E Variable. — Manufacturer: General Electric X-Ray Corp., Electromedical Section, 4855 McGeoch Avenue (W), Milwaukee 14, Wisconsin.

The G-E Variable Frequency Wave Generator is a device intended for use in stimulating denervated muscle for the prevention of atrophy.

For direct current the ripple does not exceed 0.15 per sent. The maximum output with 2,000 ohms resistance is 100 milliamperes, which is essential for all therapy or diagnosis utilizing direct current.

For sinusoidal current the deviation from the pure sine wave was plus or minus 2 per cent. The frequency of the sinusoidal current can be varied progressively from a range of 2 to 6,000 cycles per minute or 0.033 to 100 cycles per second.

Gynograph. — Manufacturer: Goodman-Kleiner Co., Inc., 5 East 17th Street, New York 3, N. Y.

The Gynograph manufactured by the Goodman-Kleiner Co., Inc., is a device which makes it possible to inject measured volumes of liquid or gas, under controlled pressures into the uterus and uterine tubes; it is designed for use in tubal insufflations with carbon dioxide, in hysterosalpingography, and in viscerographic procedures such as pneumoperitonenum. It is arranged to utilize conveniently the small cartridges in which carbon dioxide is being sold at present. The gas expands into a pressure-reducing chamber, whence it can be led into cannulas or be used to force fluids like iodized oil into the passages connected with the uterus.

Otarion Hearing Aid. — Manufacturer: Otarion Hearing Aids, 159 North Dearborn Street, Chicago 1. The Council on Physical Medicine voted to include the Otarion Hearing Aid, Model E-2, in its list of accepted devices.

Pocket Size Electronic Stethoscope. — Manufacturer: American Medical Instrument and Supply Corp., 5 North Wabash Avenue, Chicago 2. The Pocket Size Electronic Stethoscope is an instrument designed to amplify the sounds picked up during auscultatoin. The Council on Physical Medicine voted to include this instrument in its list of accepted devices.

Sylvania Infra-Red Lamps. — Manufacturer: Sylvania Electric Products, Inc., 60 Boston Street, Salem, Mass. The Council voted to include the Sylvania, 250 watt, R40, infra-red lamps in its list of accepted devices.

Center for Rehabilitation in China Is on U. S. Pattern

While numerous communities in the United States have been struggling the last few years to organize rehabilitation centers to meet the needs of their handicapped residents, there opened last June, on the outskirts of Nanking, China, a modern rehabilitation center of which any American city might be justly proud.

American communities with overcrowded hospitals might also note that the new center, like many of the Veterans Administration rehabilitation facilities in this country, is housed in eighteen Quonset huts, and a number of small buildings, pending completion of a large two-story building. Operated by the Chinese Ministry of Social Affairs, the new center has facilities for 300 beds, 100 of which are in operation.

Patterned after the recommendations of the Baruch Committee on Physical Medicine, the center provides medical services, physical and occupational therapy, vocational guidance and training and psychosocial services. Both private and public cases are referred from cooperative hospitals, and orthopedic convalescent patients are transferred to the center by some hospitals while still in plaster casts. Patients undergoing rehabilitation at the center are primarily amputees and orthopedic cases, but plans are to extend the services to other types of patients soon.—Rusk, N. Y. *Times.*

Announcing the New Journal Fertility and Sterility

A new Journal, *Fertility and Sterility,* to be sponsored by the American Society for the Study of Sterility, is announced by the publishers, Paul B. Hoeber, Inc., Medical Book Department of Harper & Brothers. The journal will be devoted to original articles, reviews and abstracts on the clinical problems of sterility and impaired fertility.

Doctor Pendleton Tompkins, of San Françisco, is the Editor. Doctor Abner I. Weisman, of New York, is Managing Editor, and the Advisory Board of twenty distinguished authorities includes Doctors C. F. Fluhmann, Alan F. Guttmacher, E. C. Hamblen, Lyman W. Mason, Joe Meigs, Lewis Michelson, G. N. Papanicolaou, John Rock, Abraham Stone, B. B. Weinstein and W. W. Williams.

Michael Canick

It is with regret we announce the death of Michael Canick of Brooklyn. Dr. Canick had been a member of the Congress for many years.

BOOK REVIEWS

HOPE IN HEART DISEASE. THE STORY OF LOUIS FAUGERES BISHOP, M.D. By *Ruth V. Bennett*. With an introduction by Ralph Ingersoll and preface by Louis Faugères Bishop, Jr., M.D. Fabrikoid. Price, $3.00. Pp. 307. Dorrance & Company, Drexel Building, Philadelphia 6, 1948.

This is a well written and quite instructive story about the first Manhattan "heart specialist," a great teacher and clinician and also a gentle mannered and modest man adored by his patients and honored by his medical confreres. It is written by his long time literary assistant. There is a preface by Dr. Bishop's son and later associate, Dr. Louis F. Bishop, Jr., himself an outstanding internist and an introduction by Ralph Ingersoll.

Dr. Bishop practiced in New York City from 1892 to 1929. He was an early enthusiast for the popularization of medical knowledge, to the benefit of the person with a heart ailment. In his writings he infused deep humanitarian and sociological understanding. In the early days of his practice there were no heart specialists. Any doctor took care of heart patients for it was simply considered another organ in the system, along with the lungs, stomach, liver, kidneys. In general, the philosophy about hearts was, "A man has to die of something, after all." The nut to crack for the hard-working medical man was how to take care of people who did not drop dead of heart disease. Medicine was waking up to the fact that, by hook or crook, many people did live on for a long time with a diseased heart, despite even a "murmur." The book offers a fascinating presentation of Dr. Bishop's background and career set up in relief against the medical profession interested in ailments of the heart in the early part of this century; it portrays the gradual development of the present day knowledge of heart disease and Dr. Bishop's outstanding role in this work, nationally and internationally. Dr. Louis Faugeres Bishop's story is synonymous with hope in heart disease. Many of Dr. Bishop's wise comments on the moving scene of American medicine, from the gay nineties to the doubtful forties, should furnish a stabilizing thought crutch to young doctors as well as brighten the memories of older physicians. An excellent portrait of Dr. Bishop on the cover of this provocative volume will be greatly treasured by many of his admirers.

MEDICAL MISSION TO AUSTRIA. JULY 1-AUGUST 8, 1947. ABRIDGED REPORT. Submitted by *Edwin Kohn*, M.D., Director of Medical Projects and Executive Director of the Medical Mission to Austria. Paper. Pp. 49, with 8 illustrations. American Unitarian Service Committee, Medical Projects, in Cooperation with World Health Organization Interim Commission, 35 E. 35th St., New York 16, 1948.

This is an abbreviated report on a medical mission organized by the Unitarian Service Committee and the World Health Organization. It followed the general scheme of the medical mission of the previous year to Czechoslovakia. In staffing this mission, the Unitarian Service Committee was deeply conscious of its responsibility, since Viennese medicine had set the standard for the world until not long ago. The choice of specialists was based on requests made by the Medical Faculty of Vienna who had asked for up to date information on thoracic surgery, brain surgery, abdominal surgery, endocrinology, virus problems, hematology, cancer research, modern anesthesia and psychiatry. Since the World Health Organization had stipulated that at least one member of the Mission be a non-American scientist, to give an international character to the Mission, two Swiss and eight American doctors were selected for the teaching staff. To dispel whatever initial reservations the Austrian scientists might have had, the Director made it abundantly clear that the Mission wanted to effect an exchange of information to acquaint the medical professions of both countries with advances made during the years of mutual isolation.

The Mission visited Vienna, Graz and Innsbruck and utilized lectures, motion pictures, informal conferences, ward rounds and surgical demonstrations in the three Austrian medical schools. Several symposia were held in which internist, psychiatrist, neurologist and pharmacologist participated in illustrating the team work principle in handling clinical problems. Each member of the team spent considerable time discussing specific and general problems with his host colleague in the three cities. In this way he also learned of the advantageous factors in each university and of the research programs being conducted in the laboratories. Portions of the team visited veterans hospitals, tuberculosis sanatoria, displaced persons hospitals and private hospitals, in addition to the University Clinics. The report contains summaries of reports of the teaching staff on each of the places visited and a number of official documents and statements as to the Mission activities. There can be no question about it that the Mission contributed to a better understanding in its important field between Austria and the United States, and that it also made a positive contribution to the processes of world peace; also that such Missions properly planned, carefully staffed and discreetly executed can go far in diffusing medical knowledge and skills and in building international goodwill and understanding.

A TEXTBOOK OF PATHOLOGY. AN INTRODUCTION TO MEDICINE. By *William Boyd*, M.D., Dipl., Psych., M.R.C.P., Edin., F.R.C.P., Lond., LL.D., Sask., M.D., Oslo, F.R.S.C., Professor of Pathology and Bacteriology of University of Toronto. Fifth Edition, revised. Cloth. Price, $10.00. Pp. 1049, with 500 illustrations and 30 colored plates. Lea & Febiger, 600 S. Washington Square, Philadelphia 6, 1947.

This textbook has enjoyed such an enviable position as to excellence over a period of many years, that it hardly needs an introduction. Medical students of many medical schools have found the subject of pathology understandable and even pleasurable because of the use of this text. In this edition the author has brought the book up to date by adding numerous new sections and revisions. The success of the previous editions can well be understood and the improvements in this new edition should make this work enjoy even greater popularity. This book can certainly be highly recommended as one of the most comprehensive, lucid and modern works on pathology.

DISEASES OF THE NOSE, THROAT AND EAR. By *William L. Ballenger*, M.D., F.A.C.S., Late Professor, School of Medicine, University of Illinois; and *Howard C. Ballenger*, M.D., F.A.C.S., Associate Professor and Acting Chairman of the Department of Otolaryngology, Northwestern University School of Medicine, Chicago; Surgeon, Department of Otolaryngology, Evanston Hospital, Evanston, Illinois. Assisted by *John J. Ballenger*, B.S., M.D., Research Fellow in Otolaryngology, Northwestern University School of Medicine, Chicago. Ninth Edition, revised. Cloth. Price, $12.50. Pp. 993, with 597 illustrations and 16 plates. Lea & Febiger, 600 S. Washington Square, Philadelphia 6, 1947.

This standard textbook still continues to maintain its place of leadership This was the first ear, nose and throat text published in this country and is now in its ninth edition and still is the outstanding work of its kind. The authors have amplified some portions of the text, obsolete material has been eliminated and new material added. The illustrations have been revised and brought up to standard excellence. While this volume will appeal to the specialists it is of no less importance to the general practitioner.

A new chapter on headaches and neuralgias of the face and head has been added. Rhinoplastic reconstruction has been described and the steps illustrated. The volume has been divided into five sections: one, the nose and accessory sinuses; two, the pharynx and fauces; three, diseases of the larynx; four, the ear; and five, bronchology, esophagology and gastroscopy.

Dr. Ballenger has had the collaboration of some of the leading specialists, Dr. J. D. Kelly, Dr. Alfred Lewy, Dr. Gabriel Tucker, and Dr. C. L. Jackson in the preparation of this work. This volume offers a complete coverage of this great field.

A full chapter is devoted to a discussion of the place of physical therapy in otolaryngology. This is well done although it would be well for the authors to change the title of the section entitled "Ionization" to that of "Ion Transfer" to conform to the nomenclature of the Council of Physical Medicine of the American Medical Association.

One notes, too, the absence of any mention in the above section of the use of electrical stimulation of the muscles during laryngeal or facial paralysis. Later, under the treatment of laryngeal paralysis, however, the authors state "that some writers have advocated the use of the faradic current" though it is difficult to see how this form of current could be effective. The authors believe that galvanism and faradism combined with external massage over the laryngeal region may increase the circulation and nutrition of the atrophied muscles.

For the physiatrist who wishes to get the proper perspective of the place of physical medicine holds in the treatment of diseases of the nose, ear and throat this book is a necessity. The book is lucidly written and has a wealth of excellent illustrations.

PHYSIOLOGY OF MUSCULAR ACTIVITY. By *Edward C. Schneider*, M.P.E., Ph.D., D.Sc., Professor of Biology, Emeritus, Wesleyan University, Middletown, Connecticut; and *Peter V. Karpovich*, M.P.E., M.D., Professor of Physiology, Springfield College, Springfield Massachusetts. Cloth. Price, $3.75. Pp. 346, with illustrations. W. B Saunders Company, 218 W. Washington Square, Philadelphia 5, Pa., 1948.

That this book fills a need is evident by the publishing of a third edition. Both authors are well known in the field of physical education. This volume was written primarily for students of physical education. Physical medicine, however, is so closely allied to physical education that everyone in the field of physical medicine will find the volume most useful. It should prove of particular interest and value as an auxiliary text of muscle physiology for student physical therapists. Instructors of courses in physical therapy will find the book practical.

This edition has been revised and a part entirely rewritten. New chapters and sections have been added. It is an excellent elementary text of the physiology of muscle, respiration and circulation, written from a specialized viewpoint, namely, the physiology of muscular activity. In addition there are excellent chapters on health and physical fitness, the relation of body type and posture to physical fitness, physical activity for convalescents, an excellent bibliography and some useful units of measurement. In the chapter on body type and posture the authors state, "It seems . . . that the physiological benefits obtained from correction of common postural deviations are mostly imaginary. Yet the authors believe that efforts should be extended in developing good

posture. The reasons for this, however, are not physiological, but esthetic." This chapter should be read by anyone interested in the problem of posture. It is an excellent and wholesome presentation.

BUILDING UP A SUCCESSFUL MEDICAL PRACTICE. By *Rodolfo V. Guiany,* M.D., Bugallon, Pangasinan, Philippines. Paper. Pp. 91. High Grade Press, New York, 1946.

A simple little booklet patterned after Dale Carnegie's "How to Win Friends and Influence People," as applied particularly to the doctor. Now that more doctors are available, a reading of the chapter entitled "How to Please Patients and Win Their Affections," might be profitable. The word "successful" in the title pertains more to the means of securing happiness in the practice of medicine and in the opportunity of supplying service to the patients rather than in the ability of improving the income. Much of the advice is a little too obvious and has been said before but one has to admire the sincerity of the author. Dr. Guiany is a general practitioner in the Philippine Islands.

THE STORY OF THE JOHNS HOPKINS: FOUR GREAT DOCTORS AND THE MEDICAL SCHOOL THEY CREATED. By *Bertram M. Bernheim,* M.D. Cloth. Pp. 235, with illustrations. Price, $3.50. Whittlesey House, A Division of the McGraw-Hill Book Co., 330 West 42nd St., New York 18, N. Y., 1948.

Four doctors made the medical side of Johns Hopkins great and created an aura of glamour and excellence that has persisted to this day — Welch, Osler, Halsted and Kelly. The story of the Hopkins is their story. All four were at the birth of Hopkins when a new era in American medical education dawned. Pathologist, physician, surgeon, gynecologist, they took the new infant to themselves and literally swept it to maturity and first rank. These men were more than doctors; they were teachers, they were executives, lecturers, advisers, even actors and propagandists. They had spirit, they had humility, they had knowledge and deep understanding of illness, disease and people.

Dr. Bernheim was born in 1880 in a little Kentucky town. He has been associated with Johns Hopkins in one capacity or another for thirty-three years. After being graduated from Johns Hopkins in 1905, he worked in laboratories in various dispensaries for five years. He became a pioneer in the field of blood transfusion beginning in 1908, and through that got started in private practice, gradually working into surgery. He has been chief surgeon of two hospitals in addition to this continuous association with Johns Hopkins. In World War I, he was in France for nearly two years as a frontline surgeon with the Johns Hopkins Unit. Dr. Bernheim is Associate Professor of Surgery Emeritus at the Johns Hopkins Hospital. He is author of several books, among them the Norton, 1947 medical prize winner "A Surgeon's Domain."

Dr. Bernheim has written a behind-the-scenes story of the famous institution which is full of the drama, the excitement and the tragedies that are all part of the life of a hospital.

OCCUPATIONAL THERAPY SOURCE BOOK. By *Sidney Licht,* M.D. Cloth. Pp. 90. Price, $1.00. The Williams & Wilkins Company, Baltimore, Md., 1948.

Believing that "to study a subject without regard to its origin is to acquire substance without spirit," Dr. Licht has here assembled some inspiring materials from the history of occupational therapy. Following a vivid chapter that summarizes earlier history, there is a collection of ten extensive quotations of classic publications in the field, French and German (in good translations) Irish, English and American. This book will bring inspiration to anyone concerned with the care of the sick and the management of hospitals and asylums.

DISEASES OF THE HEART AND CIRCULATION. By *Albert A. Fitzgerald Peel,* M.A., D.M. (Oxon.), F.R.F.P.S.(G.), Professor of Medicine, Anderson College of Medicine, Glasgow; Assistant Physician Victoria Infirmary, Glasgow; Lately Visiting Physician, E.M.S., Scotland; Medical Consultant, Department of Health for Scotland and Ministry of Labor and National Service Recruiting Boards. Cloth. Pp. 298, illustrated. Price, $9.75. Oxford Medical Publications, Oxford University Press, 114 Fifth Avenue, New York 11, N. Y.

An attempt is made in the present volume to present the morbid physiology of the circulation side by side with its morbid anatomy, and to know how these determine the symptoms and the physical signs of illness and form the basis of clinical science. The author endeavors to relate the clinical aspects of illness to its anatomy, physiology and pathology; it includes sections on subjects which are not ordinarily discussed in a course of lectures, but which should be of practical value, such as the cardiovascular system in anaemias, the heart in chest deformities, the heart in relation to pregnancy and in relation to surgical operations. The three main sections of the volume are: (1) Symptoms and physical signs in cardiovascular disease; (2) anatomical lesions; (3) the etiology of heart disease. There are 61 illustrations, diagrams, teleradiograms and electrocardiograms, amply illustrating all material included. This is a clearly written and authoritative introduction to the study of cardiovascular disease, both for students and for practitioners.

PHYSICAL MEDICINE ABSTRACTS

Series of Cases of Painful Back. J. A. Noble.
Canad. M. A. J. **58**:437 (May) 1948

The 104 cases reviewed by Noble concerned men who applied to a Department of Veterans' Affairs for relief of painful back. The average age was 33. There were only 6 over 50 years. The intervertebral disk was involved in 42 cases Postural strain, arthritis, spondylolisthesis, traumatic strain, spondylitis, tuberculosis, fibrositis and bone injury were some of the other etiologic classifications. Many cases of backache were improved by the lumbosacral brace. In particular, in patients who have had a laminectomy without subsequent fusion and who have residual symptoms referable to the back, the brace may afford considerable relief. Operations were performed on 26 of the 42 patients with disk lesions. In 5 of the 26 cases operated on, no disk protrusion was found. Sixteen of the 26 patients operated on were sufficiently restored to go back to work, but 14 of them could do only light work and only 2 could resume full duty. Of the 16 patients with disk lesions treated conservatively 11 could do light work and 4 could return to full duty; one could not be traced. Thus when a protruded intervertebral disk can be diagnosed operation may not necessarily restore the patient. A study of the nature of the trauma resulting in chronic pain in the back suggests that the best treatment may well be some form of prevention. The human species has a constitutional weakness at the lumbosacral junction. In order to compensate for this deficiency, postural training is required

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Renal Ptosis and Its Treatment. William F. Braasch; Laurence F. Greene, and Ruy Goyanna.
J. A. M. A. **138**:399 (Oct. 9) 1948.

It is surprising how many patients with renal ptosis were benefited by means of palliative and corrective measures. Although renal pads, corsets or other types of abdominal support may not keep the kidney in place, yet many of these patients stated that such support gave them much relief. The relief can be explained either on psychologic grounds, on the basis of counterirritation or on the grounds that lumbosacral pain often is helped by some form of back support. Other measures, such as increased and nourishing diet, reduction in work and periods of rest and recreation, were of definite help in some cases, particularly if a gain in weight was effected. Psychosomatic treatment has benefited many, and if skillfully employed, may be the key to recovery. Many patients were included in this list who were in the menopause and who stated that their improvement became permanent after this period had been passed.

According to these observations, it would be no exaggeration to say that the problem of nephroptosis is not a simple one. It is evident that any one who advises nephropexy without careful and thorough consideration of all the factors involved and without giving the patient the benefit of other methods of treatment is doing that patient an injustice.

The fact that the symptoms were relieved in less than 50 per cent of the patients subjected to nephropexy after careful selection would, in itself, make one hesitate before advising this operation. A conservative attitude is substantiated by the fact that many patients observed had previously undergone nephropexy elsewhere without relief of symptoms.

Rheumatoid Arthritis. The Importance of a Comprehensive Approach in Treatment. Walter Bauer.
J. A. M. A. **138**:397 (Oct. 9) 1948.

In a chronic disease of unknown cause, such as rheumatoid arthritis, characterized by unpredictable spontaneous remissions and exacerbations, it is extremely difficult to evaluate the results of treatment with any degree of certainty unless the studies are rigidly controlled. The treatment of patients with rheumatoid arthritis requires an understanding of the systemic nature of the disease, its many clinical manifestations, its varied clinical course and the persons afflicted. Until the advent of a specific therapeutic agent, treatment of this disease necessitates a comprehensive approach of the type briefly described.

A Study of Resuscitation from the Juxtalethal Effects of Exposure to Carbon Monoxide. H. Schwerma; A. C. Ivy; H. Friedman, and E. La Brosse.
Occup. Med. **5**:24 (Jan.) 1948.

This report by Schwerma and his co-workers presents the results obtained when dogs were exposed in a chamber to air containing 0.3 per cent carbon monoxide from the gas main in Chicago until the first respiratory gasp occurred. At this point the animal was immediately removed from the chamber and one of six procedures was instituted. Thirty-six per cent, or 8 of 22 dogs, survived when given manual artificial respiration in air. Forty-three per cent, or 13 of 30 dogs, survived when given manual artificial respiration in 7 per cent "carbogen." Sixty-nine per cent, or 57 of 82 dogs, survived when given mechanical artificial respiration with a device providing alternating positive and negative pressure, using 100

per cent oxygen. Sixty-six per cent, or 55 of 83 dogs, survived when given mechanical artificial respiration with the same device, using 7 per cent "carbogen." Sixty-five per cent, or 13 of 20 dogs, survived when given mechanical artificial respiration with an alternating positive pressure device, using 100 per cent oxygen. Mechanically produced artificial respiration using 100 per cent oxygen or 7 per cent "carbogen" is significantly superior to that produced manually in air. Regardless of this fact, the manual method must be taught because it is always available. Three cases of pneumonia (10 per cent) occurred among the 31 survivors resuscitated by manual artificial respiration or by being placed in "fresh air." Twenty-six cases of pneumonia occurred among 125 survivors (24 per cent) which were resuscitated with positive pressure devices. This difference is not considered significant, since it could occur by chance in 15 of 100 such experiments. The incidence of pneumonia was the same whether 100 per cent oxygen or 7 per cent "carbogen" was used for resuscitation. In regard to survival and the incidence and severity of neurologic sequelae no difference was found between the use of 100 per cent oxygen and 7 per cent "carbogen" in resuscitation from carbon monoxide asphyxia.

Skin Lesions in Persons Exposed to Beryllium Compounds. R. S. Grier; P. Nash, and D. G. Freiman.

J. Indust. Hyg. & Toxicol. **20**:228 (July) 1948

The following types of cutaneous lesions have been observed in those who came in contact with beryllium compounds; contact dermatitis, ulcer of the skin and lesions arising spontaneously in patients with the chronic type of pulmonary disease. To these should be added subcutaneous granuloma occurring in persons who cut themselves on fluorescent lamps coated with beryllium-containing phosphor. The first of the 3 cases reported by Grier and his associates was of a boy, aged 12, who was cut on the side of the neck when he hit an old fluorescent lamp. The other 2 cases concerned men who worked in fluorescent lamp factories and who were accidentally cut with a piece of a lamp. The subcutaneous granulomas which developed in these 3 patients represent a distinct form of tissue reaction to beryllium. Pathologically, these granulomas are similar to that seen in the cutaneous lesions which have arisen in the course of the pulmonary granulomatosis caused by beryllium. A similar epithelioid cell reaction has also been found in the lungs of workers who have died of pulmonary granulomatosis following exposure to beryllium compounds. In such cases beryllium has been detected spectroscopically in amounts of the same order of magnitude as was found in the subcutaneous granuloma of case 1. The histology of these granulomas may resemble cutaneous and subcutaneous sarcoidosis so closely that, in some instances, the diagnosis may be missed without a history of exposure to beryllium or determination of beryllium in the tissue. Usually, however, the lesions associated with beryllium show foci of necrosis of a type not seen in sarcoidosis, and the laminated inclusion bodies seem to occur in the former with greater frequency. The incidence of subcutaneous granulomas among those who cut themselves on these lamps is not known, but by analogy with pulmonary granulomatosis, which in one series occurred in 6 per cent of those exposed, it seems likely that in only a few such persons will granulomas develop.

Erb's Palsy. B. Wolman.

Arch. Dis. Child. **23**:129 (June) 1948.

The term Erb's palsy is applied to that type of birth palsy in which the paralysis, or paresis, is confined to muscles supplied by the fifth and sixth cervical nerves. The deltoid, supraspinatus, infraspinatus, teres minor, biceps, brachialis, brachioradialis and supinator muscles are usually involved in cases of severe disease, whereas in cases of mild disease only some of these muscles are involved. Wolman reviewed the cases seen at the outpatients' department of a busy provincial teaching hospital during the last twenty-one years. Actually 125 persons with Erb's palsy presented themselves during that time, but the author has only been successful in tracing and interviewing 37 of this group. Injury at birth to the supraclavicular portion of the brachial plexus is the accepted cause of the condition. Skilled obstetric technic in delivery, particularly in the use of forceps, is the main factor in avoiding this paralysis. Large babies are more likely to be injured. A large child in a primigravida needs special care with the delivery of the head and arms. Treatment must be carried out from birth. Infants treated within the first month do well and results are 100 per cent successful. If treatment is delayed, contractures causing impaired function of the shoulder and elbow will develop quickly. The treatment consisted of adequate splintage, associated with massage, together with exercises in older children.

Observations on Use of Respirator in Refractory Status Asthmaticus. M. F. Reiser, and E. B. Ferris, Jr.

Ann. Int. Med. **29**:64 (July) 1948.

Reiser and Ferris used anesthesia and the Drinker respirator for artificial respiration in 3 patients with acute intractable asthma. Since expiration is primarily limited in asthma, it would appear that the best procedure for the maintenance of adequate ventilation would be to support this phase. This can be effectively accomplished by the use of the Drinker respirator which applies positive pressure to the chest wall and abdomen. Since the respirator also aids inspiration, inspiratory dyspnea is at the same time decreased. In each of the 3 cases, prompt and sataisfactory relief of anoxemia was accomplished and maintained until bronchiolar spasm had undergone re-

mission. One patient was treated early in the course of his attack and recovered uneventfully. The 2 others died, but the unfavorable outcome can be explained on the basis of complicating factors and need not to be regarded as indicating failure of treatment with the respirator. While no definite conclusion can be drawn from limited experience, it is felt that the rationale is sufficiently clear, and the results, so far as relief of anoxemia is concerned, are gratifying enough to warrant the use of the respirator in refractory status asthmaticus. It is of utmost importance that the therapy be instituted early in the course before irreversible changes have appeared, or other grave complications have had time to gain foothold. This maneuver is not suggested as a substitute for other well established methods of treatment, but rather as an adjunct in refractory cases.

Investigations Into Effect of Hot, Dry Microclimate on Peripheral Circulation, Etc., in Arthritic Patients. G. Edstrom; G. Lundin, and T. Wramner.

Ann. Rheumat. Dis. **7**:76 (June) 1948.

For the last six years Edstrom and his associates have had one ward in the rheumatologic department of the University Hospital in Lund constantly air conditioned at 32 C. and 35 per cent relative humidity. In this ward they have treated arthritic patients, each of them for about a hundred days. The peripheral circulation increased in all. Peripheral vasospasm was converted into peripheral vasodilatation. The arteriovenous anastomoses especially have been maximally dilated. The temperature of the skin, which was lower at an ordinary room temperature of 20 C. (especially in cases of rheumatoid arthritis) has been raised, particularly on hands, feet and distal part of the extremities. The relative oxygen saturation of venous blood, measured at the medial cubital vein, increased in the hot rooms, while the arteriovenous difference diminished. Cultures from the throat flora showed in most cases beta-hemolytic streptococci on admission of patients to the hot room, but only in 2 cases were such cocci detected at the end of their stay. These cocci apparently do not tolerate this dry hot climate. The most obvious effects on the clinical symptoms have been: remission of periarticular edema and capsular swelling of joints, diminished shifting pains and contractures, better appetite, improved function in cases of cardiac defects and disappearance of the blue livid coloration of skin on hands and feet. Tendency to recurrence immediately after removal back into ordinary room temperature has not been observed.

Advances in Medicine. Henry Cohen.

Practitioner **161**:233 (Oct.) 1948.

No dramatic advances in the field of therapy with radioactive isotopes have recently been recorded. Lawrence, et al. have published a study of 129 patients with chronic myelogenous leukemia treated with radioactive phosphorus (P32) alone or combined with x-rays and find that a third are living or have lived for five years or more after the onset of symptoms. Studies which report beneficial results from radioactive iodine in thyrotoxicosis and posthyroidectomy recurrences continue to appear, but in cancer of the thyroid this agent has not been generally effective. For polycythemia, radioactive phosphorus appears to be the most valuable therapeutic agent now available and certain types of neoplasm have been made to secure selective irradiation of the lymphatic and reticulo-endothelial systems by injecting colloidal solutions of radioactive isotopes of certain metals (most recently gold) which are deposited in these cells. Remissions have been produced in lymphatic leukemia using these methods. Radioactive gold has also been infiltrated directly into tumor masses with, it is claimed, good results, but the observations recorded must be looked upon as more than preliminary studies. Warnings have been issued about the destructive effects on germ cells which may follow the use of radioactive isotopes and the conseqquences to progeny, but in the treatment of fatal disease this is not a major consideration. The ease with which they can be recognized in tissues has led also to their diagnostic use; for example, Rotblat and Ansell have taken advantages of the special affinity of the thyroid for iodine to use radioactive iodine in the diagnosis of substernal goitre.

The most fruitful present use of isotopes is undoubtdly the aid they give as "tracers" in the study of fundamental biological processes in animals and man. In this form such elements as phosphorus, iron, sodium, carbon and iodine can be traced in the body and their role in metabolism determined.

The Response of the Quadriceps Femoris to Progressive-Resistance Exercises in Poliomyelitic Patients. Thomas L. DeLorme; Robert S. Schwab, and Arthur L. Watkins.

J. Bone & Joint Surg. **30-A**:834 (Oct.) 1948.

The response of poliomyelitis-weakened muscles has been studied in twenty-seven quadriceps femoris muscles. The effectiveness of these power exercises for increasing strength in normal muscles and in those atrophied as a result of immobilization prompted this study. The rationale for treatment was based upon the hypothesis that, in poliomyelitis, the remaining innervated muscle fibers are normal and, therefore, possess the same potentialities for hypertrophy and power as normal muscles. Thus the degree of the muscle's response to exercise should be directly proportional to the number of muscle fibers with intact nerve supply. Results clearly indicate that poliomyelitis-weakened muscles respond in much the same fashion as do normal muscles, but to a degree proportionate to the number of remaining innervated muscle fibers.

Nineteen subjects participated in this investigation, eight males and eleven females. Eight had bilateral involvement, and therefore comprised sixteen of the twenty-seven quadriceps studied. The interval between the end of the acute stage of the disease and the initiation of exercise ranged from one to forty-nine years; therefore, changes in muscle function observed during the exercise period were probably due to exercises and not to spontaneous recovery. The ages of the participants ranged from eighteen to fifty years.

The power of normal muscles can be doubled in the first four to six weeks of exercise. Of the twenty-seven quadriceps muscles studied, fifteen doubled or more than doubled quadriceps power in the first month. The remaining twelve showed improvement, ranging from 1 per cent to 89 per cent. These results are believed to compare favorably with the response of normal muscles.

It may be generally stated that the degree of improvement in power and work capacity was approximately the same for extremely weak muscles as for muscles with greater initial strength, and that the failure to reach normal functional capacity was due to the absence of a normal number of motor units.

The ergographic data are in keeping with functional improvement observed by the patients — namely: (1) less difficulty in performances requiring strength, and (2) ability to perform for longer periods without fatigue.

The improvement reported most frequently by patients was the ability to perform ordinary activities with less effort and fatigue.

Three patients noted no improvement in functional ability as a result of exercise. They represented four of the quadriceps muscles studied, and had displayed no symptoms due to quadriceps weakness prior to exercise. Although these three had good quadriceps power before exercise, the strength of the involved extremity was considerably less than normal.

The qualitative and quantitative evidence presented supports the hypothesis that, following acute anterior poliomyelitis, the remaining innervated muscles respond to progressive-resistance exercises by an increase in strength and work capacity in much the same manner as normal muscles.

Treatment of Lupus Vulgaris With Large Doses of Calciferol: Clinical and Biochemical Appraisal: Part 1 — Clinical. J. T. Ingram and S. T. Anning.

Brit. J. Dermat. & Syph. **60**:159 (May) 1948.

Ingram and Anning believe that more than 70 per cent of patients with lupus can be cured clinically in twelve to eighteen months by daily ultraviolet light baths to the whole body, combined with improved living conditions, particularly dietetic and environmental improvements. Calciferol has a striking effect on certain cases of lupus. The authors review observations on the effects of treatment with calciferol in 158 cases of lupus and 28 other cases. Four of the 158 patients with lupus have been cured and 23 have been improved, whereas in the other 131 cases the results have been negligible. Toxic effects have been observed in 30 patients, and in an additional 25 per cent gross disturbances developed in the calcium metabolism. A high percentage of those with diffusible calcium also show impaired renal function. The permanency of this damage is not known at present. In 1 child the renal function was only 40 per cent or normal thirty-four weeks after cessation of treatment with calciferol. In general, the experience of these authors with calciferol has not been very favorable. They do not believe that it will replace treatment with light in lupus and that its definite evaluation will require considerably more time.

The Clinical Use of Sodium Fluorescein and Radioactive Diiodofluorescein in the Localization of Tumors of the Central Nervous System. George E. Moore; William T. Peyton; Samuel W. Hunter, and Lyle French.

Minnesota Med. **31**:1073 (Oct.) 1948.

The use of sodium fluorescein as an aid in the localization and diagnosis of brain tumors at operation is a simple and accurate technic. The method utilizes no special apparatus except a mercury vapor lamp, which can be obtained from one of several commercial concerns. It therefore can be carried out at any hospital in which neurosurgery is done.

The use of radiopaque dyes to outline tumors of the central nervous system has not been successful. However, calculations based on phantom experiments indicate the feasibility of the method, if the proper dyes can be synthesized. The clinical value of the use of radioactive dyes to detect brain tumors preoperatively is yet to be determined. Some of the limitations of the method are already known. "Benign" tumors, such as acoustic neuroma, fibrous meningiomas, and certain astrocytomas, do not take up enough dye to give a differential ratio of radiation large enough to be detected by the Geiger-Mueller counter. There is also a limit as to the size of tumor that can be detected. Tumors with a diameter of less than 3 cm. cannot be detected unless surrounded by an appreciable area of edema. It is hoped that improvements in the physical apparatus itself will result in greater accuracy. It should be pointed out that radioactive diiodofluorescein cannot be used for therapy. The dye is concentrated and excreted largely by the liver, and therefore, irreparable damage would be incurred by the liver before the comparatively radioresistent brain tumors received a carcinolytic dosage.

[illegible] FOR PHYSICAL THERAPY TECHNICIANS ‡

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Name and Location of School	Medical Director / Technical Director	College Affiliation	Entrance Requirements *	Duration of Course	Time of Admission	Maximum Enrollment	Tuition	Certificate, Diploma, Degree
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‡ Rep. in part Nov., 1947, with additions from J. A. M. A. 133:1149 (April 12) 1947.

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